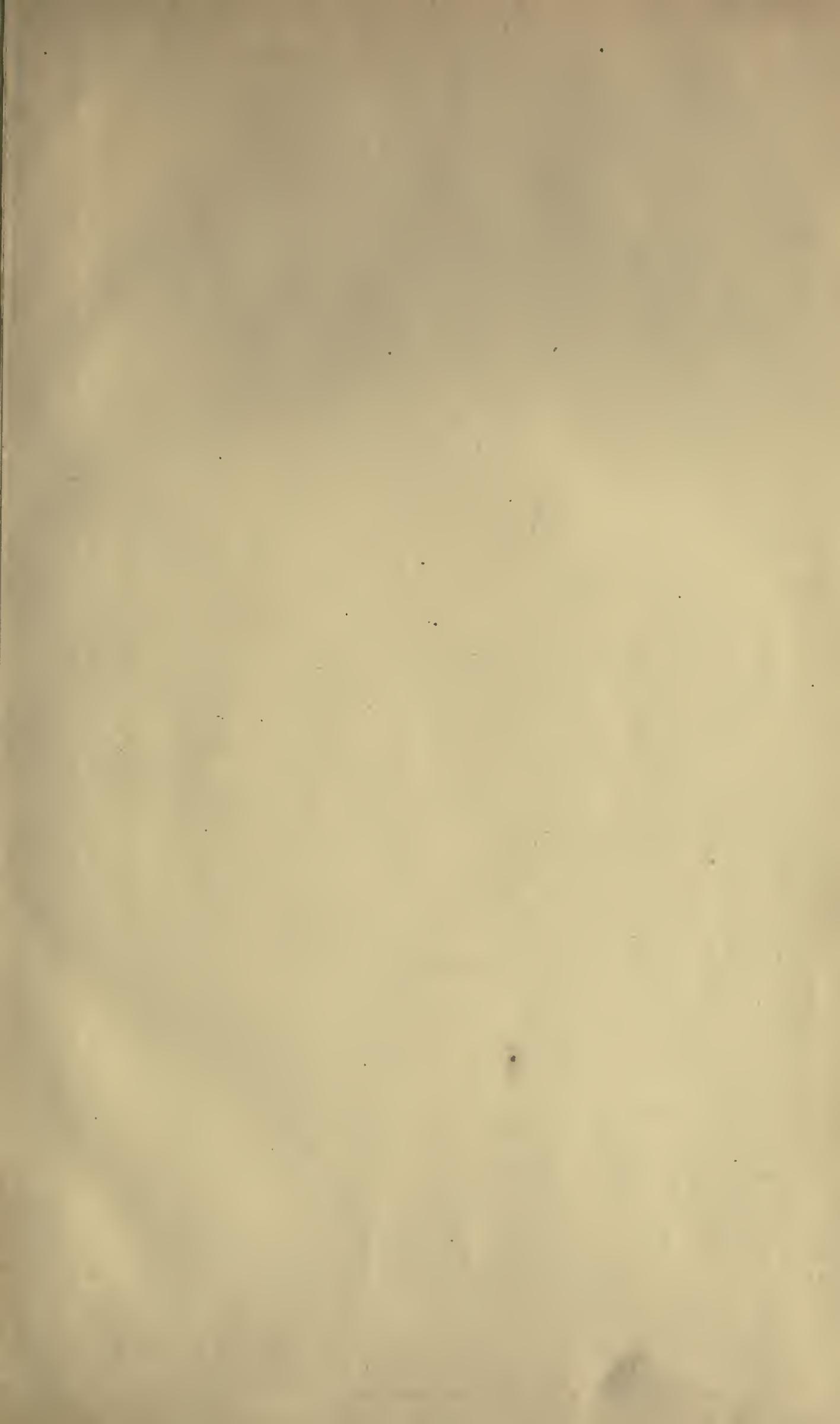




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THE STRENGTH OF  
CANADIAN DOUGLAS FIR,  
RED PINE, WHITE PINE  
AND SPRUCE.

PROFESSOR H. T. BOVEY, LL.D., F.R.S.C.

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THE STRENGTH OF  
CANADIAN DOUGLAS FIR,

RED PINE, WHITE PINE AND SPRUCE.

BY HENRY T. BOVEY, M.INST.C.E., LL.D.

(Read January 25, 1895.)

In the present Paper it is proposed to give a statement of the results which have been obtained up to the present time, from the numerous experiments which have been carried out in the Testing Laboratories, McGill University, on the strength of Canadian Douglas Fir, Red Pine White Pine and Spruce.

These experiments, which have now extended over a period of more than two years, will still be continued, and it is hoped that the results, will be set before the profession in a Paper on some future occasion.

In order that the subject may be treated in as comprehensive a manner as possible, the engineers and lumber merchants, who must necessarily be most particularly interested, are earnestly requested to give their co-operation. They can render valuable service by sending to the University Laboratories timbers of any and all sizes. These timbers should, in each case, be accompanied by a history giving the treatment of the timber from the time when the tree was felled, as, for example, the locality in which the tree grew should be specified, the manner in which the log was brought to the mill, the length of time during which it was kept in water (salt or fresh), the time during which it was kept in the pile at the mill, and, if the timber has already been in service, the length of this service. Any other details respecting the history of the timber may also be given, so that the information may in every case be as complete as circumstances will permit.

The attention of members is specially directed to the tables showing the deflection of beams under transverse loading, and also to tables showing the extension of specimens under direct tension.

These tables tend to prove conclusively the statement made by the author many years ago, *i.e.*, that timber, unlike iron and steel, may be strained to a point near the breaking point without being seriously injured. It will be observed that in almost all cases the increments of deflection and extension, almost up to the point of fracture, are very nearly proportional to the increments of load, and it seems impossible to define a limit of elasticity for timber. This probably accounts for the continued existence of many timber structures in which the timbers have been and are still continually subjected to excessive stresses, the factor of safety being often less than  $1\frac{1}{2}$ . Whether it is advisable so to strain timber is another question, and experiments are still required to show how timber is affected by frequently repeated strains.

TRANSVERSE STRENGTH.

The following Table gives in inches the distances between the centres of the end bearings ( $l$ ), the mean depths ( $d$ ) and the mean breadths ( $b$ ) of the Beams I to LXI referred to in this Paper:—

| Beams | I      | II     | III   | IV    | V     | VI    | VII    |
|-------|--------|--------|-------|-------|-------|-------|--------|
| $l$   | 96     | 66     | 66    | 69    | 69    | 69    | 69     |
|       | ×      | ×      | ×     | ×     | ×     | ×     | ×      |
| $d$   | 12.125 | 12.125 | 5.375 | 9.125 | 9.125 | 6.125 | 6      |
|       | ×      | ×      | ×     | ×     | ×     | ×     | ×      |
| $b$   | 9      | 5.625  | 4.25  | 5     | 5     | 6     | 5.8125 |

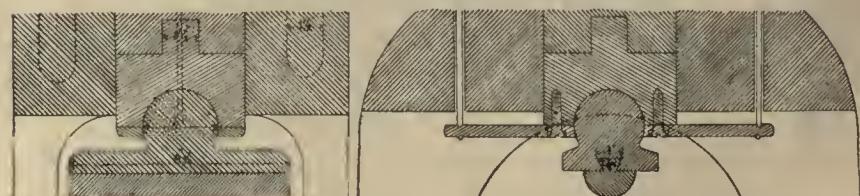
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| Beams | VIII    | IX     | X       | XI     | XII    | XIII    | XIV     |
|-------|---------|--------|---------|--------|--------|---------|---------|
| 1     | 69      | 204    | 198     | 204    | 204    | 204     | 204     |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| d     | 5.125   | 14.875 | 14.875  | 14.875 | 14.875 | 14.75   | 11.75   |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| b     | 5.5     | 9      | 6       | 8.6875 | 8.8125 | 6       | 6       |
| Beams | XV      | XVI    | XVII    | XVIII  | XIX    | XX      | XXI     |
| 1     | 198     | 198    | 138     | 138    | 138    | 138     | 138     |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| d     | 15      | 15     | 15.125  | 17.8   | 12.1   | 12      | 8.98    |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| b     | 6.125   | 6.125  | 9       | 8.76   | 9.1    | 8.88    | 5.95    |
| Beams | XXII    | XXIII  | XXIV    | XXV    | XXVI   | XXVII   | XXVIII  |
| 1     | 162     | 186    | 132     | 144    | 210    | 210     | 210     |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| d     | 15.6875 | 14.35  | 16.2    | 15.65  | 13.25  | 13.125  | 11.25   |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| b     | 7.75    | 8.78   | 7.75    | 8.2    | 6.375  | 6.1875  | 6.34375 |
| Beams | XXIX    | XXX    | XXXI    | XXXII  | XXXIII | XXXIV   | XXXV    |
| 1     | 210     | 174    | 174     | 180    | 180    | 156     | 156     |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| d     | 11.25   | 7.25   | 7.125   | 8.125  | 11.125 | 9.125   | 11.15   |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| b     | 6.25    | 6.1875 | 6.21875 | 3.1    | 3.1    | 3.125   | 3.325   |
| Beams | XXXVI   | XXXVII | XXXVIII | XXXIX  | XL     | XLI     | XLI     |
| 1     | 288     | 288    | 114     | 102    | 120    | 120     | 288     |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| d     | 18      | 18     | 18      | 18     | 18     | 18      | 18      |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| b     | 9       | 9      | 9       | 9      | 9      | 9       | 9       |
| Beams | XLIII   | XLIV   | XLV     | XLVI   | XLVII  | XLVIII  | XLIX    |
| 1     | 120     | 120    | 288     | 120    | 120    | 150     | 15      |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| b     | 18      | 18     | 18      | 18     | 18     | 15.1875 | 15.375  |
|       | ×       | ×      | ×       | ×      | ×      | ×       | ×       |
| b     | 9       | 9      | 9       | 9      | 9      | 9.375   | 9.125   |
| Beams | L       | L1     | LII     | LIII   | LIV    | LV      | LV      |
| 1     | 186     | 192    | 180     | 180    | 288    | 120     |         |
|       | ×       | ×      | ×       | ×      | ×      | ×       |         |
| d     | 15      | 15.12  | 14.85   | 15     | 17.5   | 17.5    |         |
|       | ×       | ×      | ×       | ×      | ×      | ×       |         |
| b     | 9.0625  | 9      | 9.05    | 9.05   | 8.875  | 8.875   |         |
| Beams | LVI     | LVII   | LVIII   | LIX    | LX     | LXI     |         |
| 1     | 120     | 186    | 180     | 180    | 138    | 186     |         |
|       | ×       | ×      | ×       | ×      | ×      | ×       |         |
| d     | 17.5    | 15     | 14.75   | 15     | 11.25  | 14.5    |         |
|       | ×       | ×      | ×       | ×      | ×      | ×       |         |
| b     | 8.9375  | 9      | 6       | 9      | 8.875  | 5.625   |         |

The transverse tests were carried out with the Wicksteed 100-to machine by means of a specially designed arrangement shown in the photograph on the opposite page.

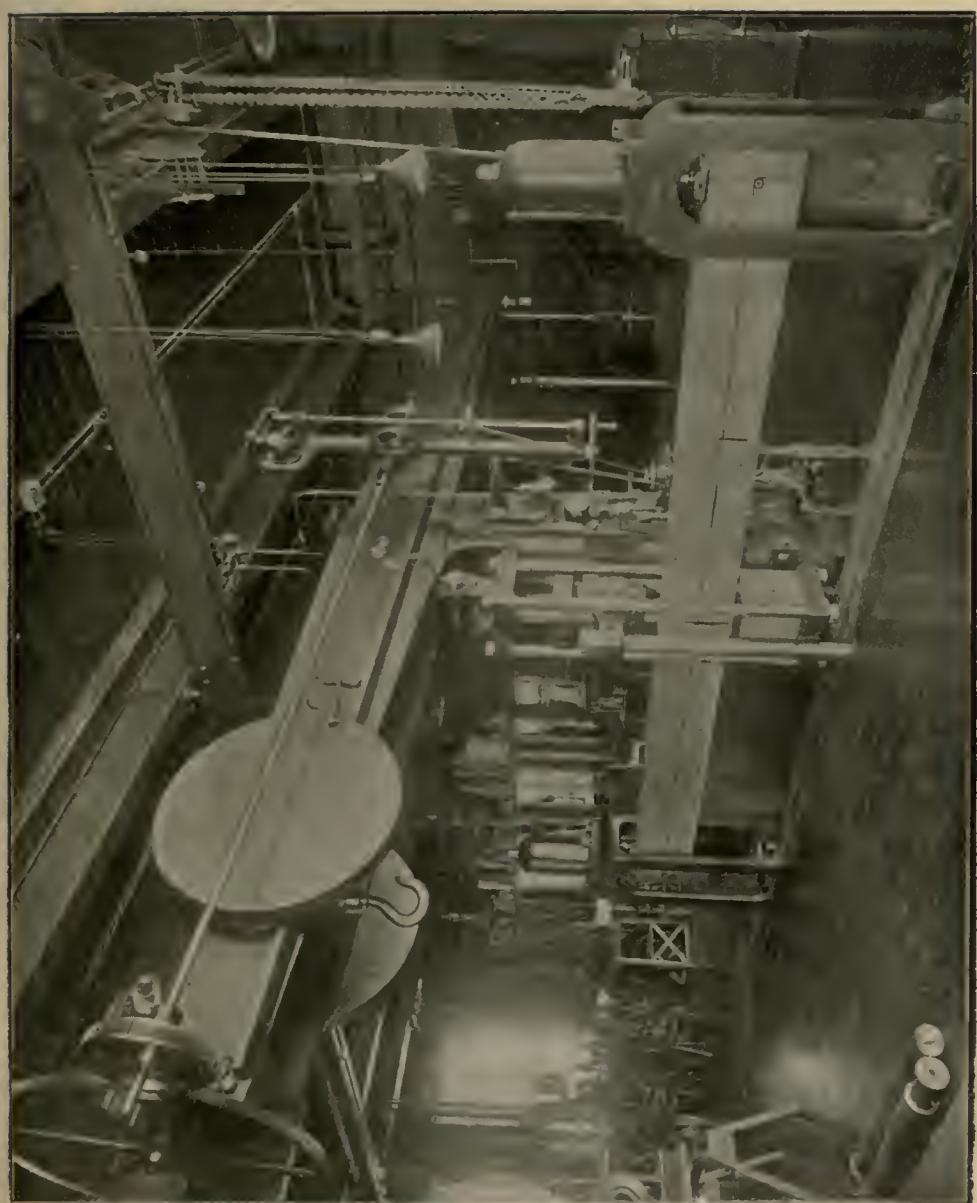
By this arrangement the two ends are gradually forced downwards while the centre is supported upon the addle suspended from the lever of the machine. Thus the two halves of the beam are really equivalent to two cantilevers loaded at the ends. By means of a very simple device, the pressure can be increased so regularly as to ensure an absolute equality in these end loads.

Figures 1 and 2 show the device employed to keep the pressure on the ends of the beam always normal to the surface. The spherical



joint allows the bearing to revolve, and by means of the prismatic slot any form of bearing surface may be introduced.

The formula used in calculating the skin-strengths and co-efficients of elasticity have been deduced by means of the ordinary theory of flexure which is based upon assumptions which actual experience shows to be far from being true. These assumptions are:—



- (a) That the beam is symmetrical with respect to a certain plane.
- (b) That the material of the beam is homogeneous.
- (c) That sections which are plane before bending remain plane after bending.
- (d) That the ratio of longitudinal stress to the corresponding strain is the ordinary (i. e. Young's) modulus of elasticity, notwithstanding the lateral connection of the elementary layers.
- (e) That these elementary layers expand and contract freely under tensile and compressive forces.

In each case, the skin stress at the point of fracture in lbs. per sq. in has been determined by means of the formula,

$$f = \frac{3}{2} \frac{l(2W_1 + W_2)}{bd^2}$$

$W_1$ -lbs. being the weight at an end,  $W_2$ -lbs. half the weight of the beam  
 $l$ -ins. the length of the beam between the two end centres of pressure,  
 $b$ -ins. the breadth and  $d$ -ins. the depth at the section of fracture.

In practice, the breaking weight,  $W_1 + \frac{1}{2}W_2$ , is usually determined from the formula,

$$W_1 + \frac{1}{2}W_2 = C \frac{bd^2}{l},$$

$C$  being the co-efficient of rupture. Hence,  $f = 3C$ .

It may perhaps be well to point out that a very small error in estimating the depth of a beam may lead to a considerable error in the calculated skin stress. Thus from the formula just given it appears that if  $\Delta f$  be the change in the skin stress corresponding to a change  $\Delta d$  in the depth, then

$$\Delta f = -2 \frac{f}{d} \Delta d,$$

and the skin stress will be increased or diminished by this amount, according as the estimated depth is too small or too great by the amount  $\Delta d$ .

For instance, in the case of the Spruce Beam No. L, the calculated skin stress, disregarding the diminution of depth due to compression, is 5123 lbs. The initial depth ( $d$ ) of the beam was 17.5 ins., and the amount of the compression ( $\Delta d$ ) 2 ins. Thus the error ( $\Delta f$ ) in the skin stress is

$$\Delta f = -2 \frac{5123}{17.5} 2 = 1171 \text{ lbs. per sq. in.},$$

and the actual stress becomes  $5123 + 1171 = 6294$  lbs. per sq. in., showing an increase of 22.8 per cent.

Now, in every example of transverse testing, the material is more or less compressed at the central support. The central support in the following examples was a hardwood block of 20 ins. diameter. The amount of the compression at this support depends not only upon the nature of the material of the beam and upon the character of the support, but also very especially upon the ratio of the length of the beam to its depth. In calculating the skin stress corresponding to the breaking weight, therefore, three assumptions may be made :—

- 1st. That the compression at the support may be disregarded.
- 2nd. That the effective depth of the beam may be taken as equal to the initial depth minus the amount of the compression, and that the usual law may be assumed to hold good for the whole of this effective depth.
- 3rd. That the compression portion of the beam is alone affected, so that the so called neutral plane remains in the same position relatively to the tension face of the beam from the commen cement of the test to the end.

Calculations based upon these three assumptions have been made in several of the following cases, and it will be observed that in all cases the skin stress calculated upon the first assumption is invariably less than the skin stress determined upon either of the remaining assumptions.

Thus any error is on the safe side.

It should be remembered, however, that it is possible, and even probable, that neither of these assumptions is even approximately correct, at all events, beyond the limit of elasticity, which in the case of timber still remains indefinite. The portion in compression doubtless acquires

increased rigidity, and thus exerts a continually increasing resistance, so that there is produced a more or less perfect equalization of stress throughout the portion of the beam under compression, and this equalization will doubtless materially affect both the elasticity and the strength.

An interesting paper on the surface-loading of beams was presented by Prof. C. A. Carus-Wilson to the Physical Society of London, (Eng.), and an abstract of this Paper is to be found in the author's treatise on the Theory of Structures.

The co-efficient of elasticity, as determined by the transverse loading, is deduced from the formula

$$E = \frac{1}{4} \frac{\Delta W}{\Delta D} \frac{l^3}{bd^3}$$

$\Delta W$  being the increment of weight corresponding to the increment  $\Delta D$  of the deflection.

Here again an error  $\Delta d$  in the estimated depth will produce an error  $\Delta E$  in the calculated co-efficient of elasticity measured by

$$\Delta E = -3 \frac{E}{d} \Delta d.$$

#### DOUGLAS FIR.

Beams I to III were sent to the Testing Laboratory by Mr. John Kennedy, Chief Engineer of the Montreal Harbour Works.

Beams I and II were of good average quality.

Beam I was tested on March 1st, 1893, with the annular rings as in Fig. 3. The load was gradually increased until it amounted to 45,000 lbs., when the beam failed by the tearing apart of the fibres on the tension face.

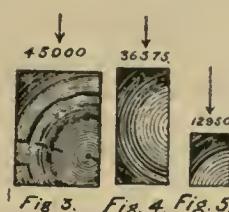
The maximum skin stress corresponding to the breaking weight of 45,000 lbs. is 4897 lbs. per square inch.

The co-efficient of elasticity, as deduced from an increment in the deflection of .23-in. between the loads of 3500 and 22,500-lbs., is 1,138,900 lbs.

Table A shows the several readings.

Beam II was tested on March 2nd, 1893, with the annular rings running as in Fig. 4.

The load was gradually increased until it amounted to 36,575 lbs. when the beam failed by shearing longitudinally.



The maximum skin stress corresponding to this breaking weight is 4378 lbs. per square inch.

In connection with this experiment it is of interest to note that the timber, although it had failed by longitudinal shear, still possessed a very large amount of transverse strength, and similar facts will be subsequently referred to in the case of other beams. After the fracture, the load upon the beam was again gradually increased to 34,000 lbs. before a second failure occurred.

The co-efficient of elasticity, as determined by the increment in the deflection of .1 in. between the loads 2000 and 18,000-lbs., is 1,146,900 lbs.

Table B shows the several readings.

Beam III was tested on March 2nd, 1893, with the annular rings as in Fig. 5.

This Beam was of especially excellent quality, with clear, close, parallel grain, perfectly sound and free from knots.

The load was gradually increased until it amounted to 12,950 lbs., when it failed by shearing longitudinally.

The maximum skin stress corresponding to the breaking load is 10,441 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .2-in. between the loads of 500 and 4500-lbs., is 2,178,100 lbs.

Table B gives the several readings.

Beams IV to VIII were sent to the laboratory by the British Columbia Mills Timber & Trading Company through Mr. C. M. Beecher.

These beams were cut out of trees grown on the coast section of British Columbia, and felled in the fall or during the winter. The whole of the beams were free from knots, of good quality, and with the grain running straight from end to end.

Beam IV was tested May 17th, 1893, with the annular rings somewhat oblique as shown in Fig. 6. Under a load of 16,720 lbs. it

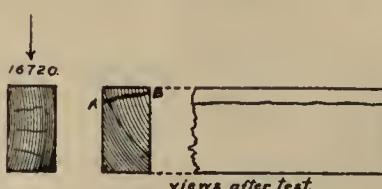


Figure 6.

failed by shearing longitudinally along a plane AB at right angles to the annular rings, the distance between the ends of the portions above and below the plane of shear being  $\frac{1}{4}$ -in. The plane of shear extended to a distance of about 36 ins. from the end of the beam.

The maximum skin stress corresponding to the breaking load is 4156 lbs. per square inch.

The co-efficient of elasticity, as determined by an increase in the deflection of .14-in. between the loads of 2,000 and 8,000 lbs., is 926,500 lbs.

Table B shows the several readings.

After the beam had sheared longitudinally, the jockey weight was run back, and the load again gradually applied until it amounted to 15,000 lbs., when fracture occurred by the tearing apart of the fibres on the tension face. Under this load of 15,000 lbs. an opening of  $\frac{1}{2}$ -in. was developed in the end at the plane of shear.

On May 11th this beam weighed 56 lbs. 13 ozs., or 28.59 lbs. per cubic foot. On May 17th, the weight of the beam was 56 lbs. 3 ozs., or 28.27 lbs. per cubic foot, so that while in the laboratory this beam lost in weight at the rate of .0533-lb. per cubic foot per day.

Beam V was tested on May 19th, 1893, with the annular rings somewhat oblique as shown in Fig. 7. It failed by the tearing apart of the fibres on the tension face under a load of 23,610 lbs.

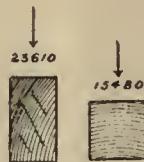


Fig. 7 Fig. 8.

The maximum skin stress corresponding to this load is 5869 lbs per square inch.

The co-efficient of elasticity, as determined by an increase in the deflection of .24-in. between the loads of 1000-lbs. and 11,500-lbs., is 946,270 lbs.

Table B shows the several readings.

The weight of the beam on May 11th was 59 lbs., or 29.59 lbs. per cubic foot. The weight of the beam on May 19th was 58 lbs. 3 ozs., or 29.18 lbs. per cubic foot, so that the loss in weight in the laboratory was at the rate of .05125-lb. per cubic foot per day.

Beam VI was tested May 22nd, 1893, with the annular rings as in Fig. 8. Under a load of 15,480 lbs. it failed by the tearing apart of the fibres on the tension face.

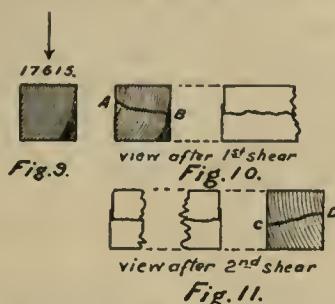
The corresponding maximum skin stress is 7116 lbs.

The co-efficient of elasticity as determined by an increase in the deflection of .3-in. between the loads of 500-lbs. and 8,000-lbs. is 1,489,215 lbs.

Table B shows the several readings.

The weight of the beam on May 11th was 49 lbs. 6 ozs., or 31.05 lbs. per cubic foot, and the weight on May 22nd was 48 lbs. 1 oz., or 30.23 lbs., showing a loss of weight while in the laboratory at the rate of .0745-lb. per cubic foot per day.

Beam VII was tested on May 19th, 1893. In this beam the annular rings ran somewhat obliquely as in Fig. 9. Under a load of 17,615 lbs., the beam sheared longitudinally along the plane AB, Fig. 10, the distance between the ends of the portions above and below the plane of shear being 3-16ths of an inch. The plane of shear extended to a distance of 46-ins. from the end of the beam.



The maximum skin stress corresponding to this breaking weight of 17,615 lbs. is 8712 lbs.

The co-efficient of elasticity, as determined by an increase in the deflection of .255-in. between the loads of 500 lbs. and 8500 lbs., is 2,052,250 lbs.

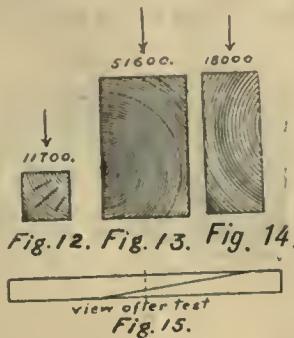
Table B shows the several readings.

Immediately after the longitudinal shear the jockey weight was run back until it indicated a load of 5090 lbs. when the lever again floated. The weight was then gradually increased until it amounted to 11,840 lbs., when there was a second longitudinal shear along the plane CD at the other end, Fig. 11. The gap at the plane AB was now increased from 3-16ths in. to 3-10ths in., and the distance between the ends of the portions above and below the plane of shear at the other end of the beam was 3-20ths of an inch.

After this second shear the jockey weight was run back to 6840 lbs when the lever floated. The load was gradually increased until it amounted to 8990 lbs., when the beam was fractured by the tearing apart of the fibres on the tension face.

On May 11th, this beam weighed 60 lbs. 4 ozs., or 40.69 lbs. per cubic foot, and the weight on May 19th was 59 lbs. 2 ozs., or 39.92 lbs. per cubic foot, showing a loss of weight in the laboratory at the rate of .09625-lb. per cubic foot per day.

Beam VIII was tested May 22nd, 1893. In this beam the annular rings were oblique as in Fig. 12. Under a load of 11,700 lbs. it failed at the support by the tearing apart of the fibres on the tension face.



The maximum skin stress due to this load is 8382 lbs. per square inch.

The co-efficient of elasticity, as determined by an increase in the deflection of .32-in. between loads of 1000 lbs. to 5500 lbs., is 1,559,950 lbs.

Table B shows the several readings.

The weight of this beam on May 11th was 44 lbs., or 36.76 lbs. per cubic foot, and its weight on May 22nd was 42 lbs. 14 ozs., or 35.74 lbs. per cubic foot, showing a loss of weight in the laboratory at the rate of .0927-lb. per cubic foot per day.

Beams IX to XVI were sent to the laboratory by Mr. P. A. Peterson, chief engineer of the Canadian Pacific Railway.

Beam IX was grown on the mainland half way between Vancouver and New Westminster, in a flat country not much above the sea level. It was cut from a log 26 ins. in diameter and 34 feet in length, which was felled about the month of May, 1892. The log was floated to the mill at Vancouver, and lay in fresh water for ten months.

The timber corresponded to first quality in the market, its grain being straight and running parallel to the axis. It contained a season crack on the widest face, about 11 feet long,  $3\frac{1}{2}$  ins. below the edge, and about  $1\frac{1}{2}$  in. deep. The beam was tested Nov. 13th, 1893, with the annular rings as in Fig. 13, the heart of the tree being in one of the vertical faces. Under a load of 51,600 lbs. this beam failed at the support by the tearing apart at the centre of the fibres on the tension face.

The maximum skin stress corresponding to this load is 7974-lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .77-in. between the loads of 1000-lbs. and 20,000-lbs., is 1,767,990 lbs.

Table C shows the several readings.

The weight of the beam was 603 lbs., or 36.49 lbs. per cubic foot on Oct. 3rd, 590 lbs. 13 ozs., or 35.76 lbs. per cubic foot on Nov. 10th, and 590 lbs. on Nov. 13th, showing a loss of weight while in the laboratory at the rate of .0195-lb. per cubic foot per day.

Beam X. This beam was tested Nov. 11th, 1893, with the annular rings as in Fig. 14. It was cut from a log 32 ins. in diameter grown on the mainland 120 miles north and west of Vancouver, on a hill side about 100 feet above the sea-level. The log was felled in the winter of 1892-93, and was then towed to the mill, and remained in salt water six months.

The grain in this beam ran crosswise, and it failed by a cross fracture along the plane AB, Fig. 15.

The fracture occurred under a load of 18,000 lbs., corresponding to a maximum skin stress of 4027 lbs. per square inch. The co-efficient of elasticity, as determined by an increase in the end deflections of .84-in. between the loads 1000-lbs. and 15,000 lbs., is 1,637,806 lbs.

Table C shows the several readings.

The weight of the beam was 407 lbs. 2 ozs., or 38.94 lbs. per cubic foot on Oct. 3rd, 406 lbs. 8 ozs., or 37.80 lbs. per cubic foot on Nov. 10th, and 404 lbs. 13 ozs., or 37.79 lbs. per cubic foot on Nov. 13th, showing a loss of weight in the laboratory at the rate of .03-lbs. per cubic foot per day.

Beam XI. This beam was tested November, 7th, 1893, with the annular rings as in Fig. 16. Its history is the same as that of Beam



Fig. 16.

X. The timber was of a quality corresponding to first quality in the market, and the grain for the most part was parallel with the axis. It contained a few season cracks. On the tension face of the beam the fibres crossed from back to front in a distance of  $3\frac{1}{2}$  ft., commencing about five feet from one end. The beam contained the heart of the tree, the annular rings being as in the Figure.

Under a load of 35,800 lbs. the beam failed by the tearing apart of the fibres on the tension face.

The maximum skin stress corresponding to this load is 5698 lbs. per square inch.

The coefficient of elasticity, as determined by an increase in the deflection of .545-ins. between the loads of 2500 and 15,500 lbs., is 1,770,563 lbs.

Table D shews the several readings.

The weight of the beam was 595 lbs. 2 ozs., or 37.76 lbs. per cubic foot on October 3rd, and 583 lbs., or 36.99-lbs. per cubic foot on Nov. 11th, showing a loss of weight in the laboratory at the rate of .0183 lbs. per cubic foot per day.

Table D shews the several readings.

The time occupied by the test was 29 minutes.

Beam XII was tested Nov. 18th, 1893, with the annular rings as in Fig. 17. This beam was cut from a log 28 ins. in diameter, grown probably about 30 feet above the sea level at Port Grey, about eight miles from Vancouver. The tree was felled in August, 1892; it remained in salt water nine months, being alternately wet and dry according to the tide; it was then towed to the mill and cut up.

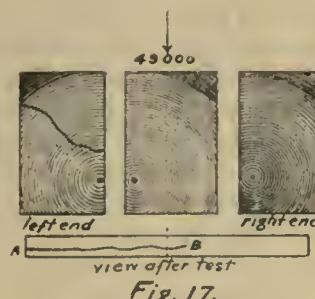


Fig. 17.

The grain was straight and parallel to the axis, and the timber was of good quality corresponding to first quality in the market. It shewed several knots of medium size and a few season cracks. The beam contained the heart of the tree, the annular rings being as in Fig.

Under a load of 49,000 lbs. the beam failed by shearing longitudinally along the season crack AB.

Under this load the maximum skin stress is 7,645 lbs. per sq. in.

The coefficient of elasticity as determined by an increment in the deflections of .545 ins. between the loads 2,500-lbs. and 15,000 lbs., is 1,678,300 lbs.

Table D shews the several readings.

The time occupied by the test was 37 minutes.

The weight of the beam was 572 lbs., or 35.65 lbs. per cubic foot on Oct. 3rd, and 558 lbs. 4 ozs., or 34.79 lbs. per cubic foot on Nov. 17th showing a loss of weight in the laboratory at the rate of .0191 lbs. per cubic foot per day.

Beam XIII. The history of this beam is the same as that of Beam IX. The beam was tested on Nov. 17th, 1893. The heart of the tree was in one of the faces, the annular rings being as in Fig. 18.

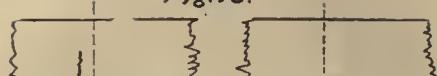
The timber was in good condition and of a quality corresponding to first quality in the market; there were small season cracks along the back of the beam, in the neighbourhood of the neutral plane, and there were also small season cracks along the whole of the front about 3-ins. above the face in compression.

Under a load of 29,300 lbs. this beam failed by the crippling of the fibres on the compression face, commencing at a small knot at the back, Fig. 19.

29300



Fig. 18.



front and back views, at centre, after test

Fig. 19.

The maximum skin stress corresponding to this load is 6912 lbs. per square inch.

The coefficient of elasticity as determined by an increase in the deflection of .805-ins. between the loads 1000-lbs. and 13,000 lbs. is 1,643,193 lbs.

Table E shows the several readings.

The beam weighed 381 lbs. 15 oz., or 34.56 lbs. per cubic foot on Oct. 3rd, and 375 lbs., or 34.13 lbs. per cubic foot on Nov. 15th, showing a loss of weight in the laboratory at the rate of .01 lb. per cubic foot per day.

The time occupied by the test was 45 minutes.

Beam XIV is in reality Beam XIII re-tested, the second test having been made Dec. 2nd, 1893. The beam was replaced in the machine with the crippled side reversed so as to be in tension. The load was then gradually applied until it amounted to 17,600 lbs., when the beam failed on the tension side by the tearing apart of the fibres along the surface at which the crippling took place on the previous test.

The maximum skin stress corresponding to this load is 4082 lbs. per square inch as compared with 6912 lbs. per square inch in the first test. The coefficient of elasticity, as determined by an increment in the deflection of .51 ins. between the loads of 1,000 lbs. and 8,000 lbs., is 1,513,950 lbs. as compared with 1,643,193 lbs. in the first test.

Table E shews the several readings.

This experiment therefore shews that although the beam may have been crippled by undue pressure, it still retained a large amount of strength as well as elasticity.

Table E gives the several readings.

Beam XV. This beam was tested Nov. 18th, 1893. The timber was excellent in quality, equal to first quality in the market, clear and straight grained and free from knots. Its history is the same as that of Beam XIII. The annular rings were oblique as in Fig. 20.

37000



Fig. 20.



front view, at centre, after test

Fig. 21.

Under a load of 37,000 lbs. the beam failed by the crippling of the fibres on the compression face, Fig. 21.

The maximum skin stress corresponding to this load is 8020 lbs. per square inch.

The total compression of the material was .34-in., and the maximum skin compressive stress, taking 1466-in., as the effective depth, is 8189-lbs. per sq. in, the corresponding skin tension stress being 8577 lbs. per in. sq.

Assuming the ordinary law to hold good for the whole of the effective depth, the maximum skin stress would be 8511 lbs. per sq. in.

The coefficient of elasticity as determined by an increment in the deflection of .755-ins. between the loads, 2000 lbs. and 18,000 lbs., is 1,989,400 lbs.

Table E shews the several readings.

The time occupied by the test was 30 minutes.

The weight of the beam was 445 lbs. 6 ozs., or 39.99 lbs. per cubic foot on Oct. 3rd, and 433 lbs. 13 ozs., or 38.92 lbs. per cubic foot on Nov. 17th, showing a loss of weight in the laboratory at the rate of .0237 lbs. per cubic foot per day.

Beam XVI. This is really Beam XV re-tested, the second test having been made on Dec. 8th, 1893. In the first test the beam had failed by crippling on the compression face; the beam was now reversed, and under a load of 25,580 lbs. it failed by the tearing apart of the fibres on the tension face along the surface at which the crippling had previously taken place. The tensile fracture extended 2 inches below the skin. The jockey weight was now run back until the lever again floated, and the load was gradually increased until it amounted to 32,000 lbs., when the beam fractured a second time on the tension side the fracture extending to a depth of 5 inches below the skin. The first fracture was accompanied by a longitudinal opening (as in Fig.) about 60 inches in extent. A second longitudinal opening, also about 60 inches long, occurred at the second fracture.

The maximum skin stress corresponding to the breaking load of 25,580 lbs. is 5466 lbs. per square inch.

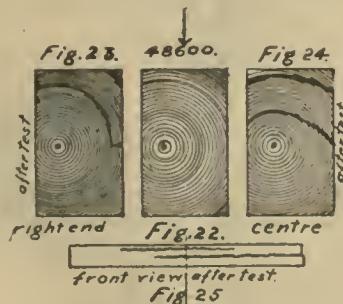
The coefficient of elasticity, as determined by an increment in the deflection of .54 ins. between the loads of 1,000 lbs. and 11,500 lbs., was 1,825,450 lbs.

Table E gives the several readings.

The weight of the beam was reduced to 428 lbs., or 38.40 lbs. per cubic foot, showing a loss between the test on Nov. 17th, and that on Dec. 8th, at the rate of .02476 lbs. per cubic foot per day.

Beams XVII to XXI were sent to the testing laboratories by the British Columbia Mills Timber & Trading Company through Mr. C. M. Beecher. The whole of these timbers were cut on the coast section of British Columbia. The trees from which Beams XVII, XVIII, XX and XXI were cut, were felled during the summer of 1893, and came from Hartney's Camp, Seymour Creek, while Beam XIX was cut from a tree felled in the spring of 1894, and came from Rowling's Camp, Salmon Arm.

Beam XVII was tested June 24th, 1894. This beam was coarse grained, the grain running very nearly parallel with the axis, and it contained a number of small knots on the compression side. It was cut from the heart of the tree, and was tested with the annular rings as in Fig. 22.



Under a load of 48,600 lbs. it failed by the tearing apart of the fibres on the tension face, the corresponding maximum skin stress, neglecting the compression of the timber, being 4906 lbs. per square inch. The tensile fracture was followed immediately by a longitudinal shear, coincident with the neutral plane at the centre of the beam, and extending for a distance of 8 feet from the end, Fig. 25. The distance between the portions of the beam above and below the plane of shear at the end

was 3-10ths of an inch. Figs. 23 and 24 are sections at the end and at the centre showing the nature of the fractures.

The total compression of the material was 1.83 ins., and the maximum skin compressive stress, taking 13.295 ins. as the effective depth, is 5193 lbs. per square inch, the corresponding stress in the tension skin being 6851 lbs. per square inch.

Assuming the ordinary law to hold good for the whole of this effective depth, the maximum skin stress would be 6350 lbs. per square inch.

The coefficient of elasticity as determined by an increment in the deflection of .335-ins. between the loads 10,000-lbs. and 30,000-lbs., is 1,259,600 lbs.

Table F gives the several readings.

The weight of the beam, when shipped from Vancouver about April 21st, was 428 lbs., or 37.21 lbs. per cubic foot; on reaching the Laboratory on June 9th, the weight was found to be 411 lbs. 10 ozs., or 35.78 lbs. per cubic foot, and on the day of the test, namely, June 24th, the weight was 404 lbs. 8 ozs., or 35.17 lbs. per cubic foot, showing a loss at the rate of .02918-lb. per cubic foot per day between Vancouver and the laboratory, and a loss at the rate of .04067-lb. per cubic foot per day while in the laboratory.

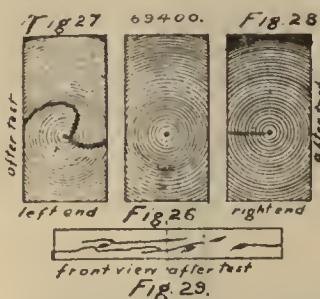
Beam XVIII. This beam was coarse grained, and contained several large and small knots; it was cut from the heart of the tree. It was tested Sept. 28th, 1894, with the annular rings as in Fig. 26.

The load on the beam was gradually increased to 12,000 lbs. The beam was now gradually relieved from strain until the load had been reduced to 1000 lbs. without showing any set. The load was again gradually increased from 1000 lbs. up to 19,000 lbs., when the beam was again relieved from load and the readings were taken for each difference of 1,000 lbs.

When the load had been reduced to 1000 lbs., the deflection at the centre was observed to be .015-in. as compared with .005-in. in the forward movement, and as soon as the beam was relieved of this 1000 lbs., it returned to its initial condition without showing any set whatever.

The time occupied by the first loading was 10 minutes, by the second loading 12 minutes, and by the relieving from load 8 minutes.

In the final test the load was gradually increased from nil until it amounted to 69,400 lbs., when the beam failed by shearing longitudinally, the shear being immediately followed by the tearing apart of the fibres on the tension face, Figs. 27, 28, 29.



The maximum skin stress corresponding to the breaking load was 5196 lbs. per square inch.

The coefficient of elasticity, as deduced from an increment in the deflection of 1-10th of an inch between the loads of 2000 lbs. and 12,000 lbs., being 1,329,900 lbs.

Table F gives the several readings.

The weight of the beam at the date of shipment from Vancouver, April 21st, was 512 lbs., or 39.08 lbs. per cubic foot. On reaching the laboratory, on June 9th, this weight was 492 lbs. 10 ozs., or 37.60 lbs. per cubic foot, and the weight on Sept. 25th was 466 lbs. 6 ozs., or 35.59 lbs. per cubic foot, showing a loss in weight between Vancouver and the laboratory at the rate of .0302-lb. per cubic foot per day, and a loss of weight in the laboratory at the rate of .0181-lb. per cubic foot per day.

Beam XIX. This beam was of exceptionally good quality, with clear close grain and no knots. It was tested Oct. 2nd, 1894, with the annular rings nearly vertical, as in Fig. 30.

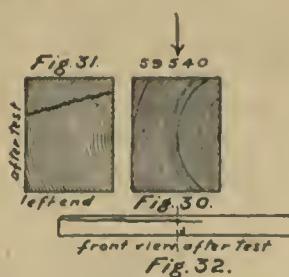


Fig. 32.

The load on the beam was gradually increased up to 16,000 lbs., when it was gradually relieved from load, the readings being taken for each diminution of 4000 lbs. The corresponding readings are indicated in Table F.

When it was completely relieved from load, the scales showed readings of .005-in at the centre, .001-in and .003-in at the ends. These readings were probably due to inequalities in the timber or a possible sliding of the scales, as the beam showed no evident sign of set.

The load was again immediately increased gradually from nil until it amounted to 59,540 lbs., when the beam failed by longitudinal shear, followed by the splintering of the upper edges on the tension side, Figs. 31, 32. Fracture was also indicated by the erippling of the fibres on the compression side taking place between 58,000 and 59,540 lbs.

The distance between the portions of the beam above and below the plane of shear at the end was .36-in. as in the figure.

The maximum skin stress corresponding to the breaking load is 9043 lbs. per square inch.

The coefficient of elasticity, as deduced by an increase in the deflection of .3-in. between the loads of 2000-lbs. and 16,000 lbs., is 1,934,600 lbs.

Table F shows the several readings.

The time occupied by the first loading was  $10\frac{1}{2}$  mins., by the relieving from the load  $6\frac{3}{4}$  mins., and by the second loading from nil to the max.,  $15\frac{1}{2}$  mins.

The weight of this beam on April 21st, the date of its shipment from Vancouver, was 410 lbs., or 44.99 lbs. per cubic foot. On reaching the laboratory the weight was 392 lbs. 8 ozs., or 43.07 lbs. per cubic foot, and the weight on Oct. 2nd, the date of the test, was 375 lbs. 10 ozs., or 41.22 lbs. per cubic foot, showing a loss of weight at the rate of .0392-lb. per cubic foot per day between Vancouver and the laboratory, and a loss at the rate of .0161-lb. per cubic foot per day while in the laboratory.

Beam XX. This beam was cut from the heart of the tree, and was tested Nov. 3rd., 1894, with the annular rings as in Fig. 33.

It was coarse grained, the grain being very nearly parallel with the axis, and contained a number of knots.

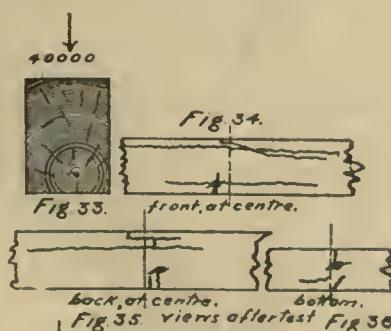


Fig. 35. views after test Fig. 36.

The load was gradually increased until it amounted 12,000 lbs., and at this point the beam was gradually relieved from load, readings being taken for every diminution of 2000 lbs. When the load had been reduced to 500 lbs., the reading at the centre was .001-in., probably due to a movement of the scale. The load was again gradually increased

until it amounted to 40,000 lbs., when the beam failed by the crippling of the fibres on the compression side in the neighbourhood of a small knot  $1\frac{1}{4}$  in. above the compression face, Figs. 34, 35, 36. The crippling extended about 4 ins. above this face. The load was still gradually increased until it amounted to 49,600 lbs., when the beam again failed by the tearing apart of the fibres on the tension face.

The maximum skin stress corresponding to the load of 40,000 lbs., and disregarding the compression of the timber, is 6559 lbs., and the skin stress corresponding to the load of 49,600 lbs., is 8127 lbs. per square inch.

The total compression of the timber was .345-ins., so that taking the effective depth under this load to be 11.655 ins., the maximum skin compressive stress would be 6710 lbs. per square inch, the corresponding skin tensile stress being 7125 lbs. per square inch.

Assuming the ordinary law to hold good for the whole of the effective depth, the maximum skin stress would be 6936 lbs. per square inch.

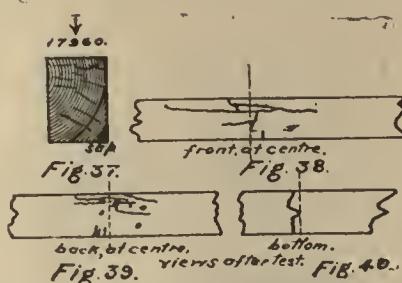
The co-efficient of elasticity, as deduced from a change in the deflection of .22-in. between the loads 4000 lbs. and 12,000 lbs., both forwards and while being relieved from load in the first reading, and also during the second loading, is 1,571,150 lbs.

Table G shows the several readings.

The weight of this beam when shipped from Vancouver, April 21st, was 349 lbs., or 41.16 lbs. per cubic foot; when delivered at the laboratory on June 9th, it weighed 329 lbs., or 36.70 lbs. per cubic foot, and on Nov. 3rd it weighed 311 lbs.  $6\frac{1}{2}$  ozs., or 34.92 lbs. per cubic foot, showing a loss of weight between Vancouver and the laboratory at the rate of .091-lb. per cubic foot per day, and a loss while in the laboratory at the rate of .0121-lb. per cubic foot per day.

The time occupied by the test was 26 mins.

Beam XXI. This beam was tested Nov. 3rd, 1894, with the annular rings as in Fig. 37.



The load upon the beam was gradually increased until it amounted to 6000 lbs., when it was gradually relieved of load, at the rate of 1000 lbs. for each observation, and the beam returned to its initial condition without showing any sign of set. The load was again gradually increased until it amounted to 17,960 lbs., when a sharp fracture took place by the tearing apart of the fibres on the tension side, and this was accompanied by a simultaneous crippling of the fibres on the compression side, Figs. 38, 39, 40.

The maximum skin stress corresponding to the load of 17,960 lbs. is 7787 lbs. per square inch.

The total compression of the timber at the centre was .16-in., so that taking the effective depth at the centre to be 8.82 ins., the maximum skin compressive stress at the point of fracture is 7901 lbs. per square inch, the corresponding skin tensile stress being 8221 lbs. per sq. in.

Assuming the ordinary law to hold good for the whole of the effective depth, the max. skin stress would be 8100 lbs. per sq. in.

The co-efficient of elasticity, as deduced by a change in the deflection of .48-in. between the loads of 10,00-lbs. and 6000 lbs., during the first loading, and while being relieved of load, is 1,588,400 lbs.

Table G shows the several readings.

The weight of this beam when shipped from Vancouver, April 21st, was 164 lbs., or 38.86 lbs. per cubic foot; when received at the laboratory on June 9th, the weight was 151 lbs. 4 ozs., or 33.02 lbs. per cubic foot, and on Nov. 13th, the date of test, the weight was 139 lbs.  $10\frac{1}{2}$

ozs., or 30.83 lbs. per cubic foot, showing a loss of weight between Vancouver and the laboratory at the rate of .1192-lbs. per cubic foot per day, and a loss of weight while in the laboratory at the rate of .0149 lbs. per cubic foot per day.

The time occupied by the test was 18½ mins.

#### OLD DOUGLAS FIR.

Beams XXII-XXV were sent to the Laboratory by Mr. P. A. Peterson, Chief Engineer of the Canadian Pacific Railway.

These beams were four old stringers taken from trestles numbered 428, 35, 316 and 789.

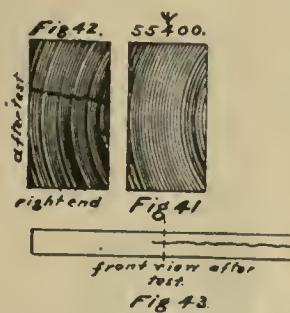
Trestle 428 is about half way between Ciseo Cantilever Bridge and Lytton. It was erected in the early summer of 1884, and the timbers had consequently been in position for nine years. It is in a dry country, with very little rainfall, and subject to a hot sun in summer. The stringer from this structure was cut out of a log probably grown on a flat about three miles west of Hope, where most of the trees were wind-shaken.

Trestle No. 35 is about one mile west of Port Moody, and was built in the early spring of 1887, so that the stringer was in position for a period of 6½ years in a place subject to the heaviest rainfall in the province. The stringer was cut from a log most probably grown at Point Grey, about eight miles from Vancouver.

Trestle No. 316 is two miles east of Spuzzum. The stringer from this trestle was cut from a log grown on a bench near Spuzzum about 500 feet above the sea-level. It was prepared and framed in 1881, and erected in 1882, so that it was eleven years in position in a district with a climate similar to that of Nova Scotia. As the railway here runs north and south, the sun had not the same effect upon the stringers as on other parts of the line.

Trestle No. 789 is on Kamloops Lake, six miles east of Savona, and was erected in the spring of 1885, so that the timbers had been in service for a period of eight years. The neighbourhood is dry, but the trestle, being situated under a high bluff, is protected from the afternoon sun. The stringer from this structure was cut out of a log probably grown about three miles west of Hope, at the same place as the timbers used in structure No. 428.

Beam XXII from Trestle 428, was tested Nov. 25th, 1893, with the annular rings as in Fig. 41.



There were two vertical 1-in. bolt holes in the timber,—one near the centre and one at the end. There were also several season cracks in the timber, one being somewhat large.

The load upon the beam, was gradually increased until it amounted to 55,400 lbs., when the beam failed by a longitudinal shear, as in Figs. 42, 43.

The distance between the portions of the beam above and below the plane of shear at the end was ⅝ths of an inch.

The maximum skin stress corresponding to the breaking load is 7086 lbs. per square inch.

The total compression of the timber at the centre was .63-in., so that taking the effective depth at 15.0575 ins., the maximum skin compressive stress is 7264 lbs. per square inch, the corresponding tensile skin stress being 7898 lbs. per square inch.

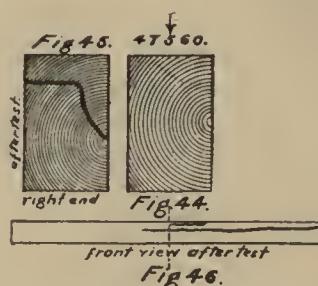
Assuming the usual law to hold good for the whole of the effective depth, the maximum skin stress would be 7,382 lbs. per square inch.

The co-efficient of elasticity, as deduced by an increase in the deflection of .39 in. between the loads of 2,000 lbs. and 20,000 lbs., is 1,639,500 lbs., while it is 1,691,620 lbs. for an increment in the deflection of .42 in. between the loads 2,000 lbs. and 22,000 lbs.

Table II gives the readings under the several loads.

The weight of the beam on the day of test was 33.75 lbs. per cubic foot, and the total weight on Oct. 3rd was 438 lbs. 7 ozs.

Beam XXIII from Trestle No. 789 was tested Nov. 28th, 1893, with the annular rings as in Fig. 44, and showing the heart in one of the faces.



The load upon the beam was gradually increased until it amounted to 47,560 lbs., when the beam failed by the tearing apart of the fibres on the tension face, which was immediately followed by a longitudinal shear, as in Figs. 45, 46.

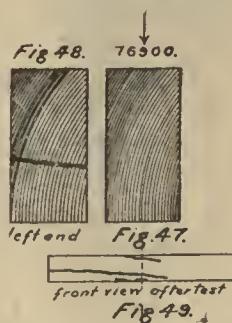
The maximum skin stress corresponding to the load of 47,560 lbs. is 7339 lbs.

The co-efficient of elasticity, as deduced from an increment of .66 in. in the deflection between the loads of 2,000 lbs. and 22,000 lbs., is 1,878,950 lbs.

Table I shows the readings under the various loads.

The total weight of the beam on Oct. 3rd was 654 lbs. 12 ozs., or 38.95 lbs. per cubic foot; the total weight on Nov. 28th, the date of test, was 549 lbs. 8½ ozs., or 38.59 lbs. per cubic foot, showing a loss of weight in the laboratory at the rate of .00643 lbs. per cubic foot per day. Estimating the weight of this beam from a solid block cut out of the beam, it was found to be 39.13 lbs. per cubic foot, or .54 lb. per cubic foot heavier than the weight deduced from the total weight of the whole beam.

Beam XXIV from Trestle No. 35. This beam was tested Nov. 25th, 1893, with the annular rings as in Fig. 47. It contained two vertical  $\frac{3}{4}$ -in. bolt holes about half way between the centre and ends, and a few knots of average size appeared on the face. It also contained several season cracks.



The initial load, including the weight of the beam, was 5,000 lbs., and the load was gradually increased up to 41,000 lbs., when the material at one end of the beam was crushed in. The ends of the beam were found to be very much the worse for wear and in a rotten condition. Releasing the beam from load the ends were sawn off and the beam was replaced at 9-ft. centres, when the load was gradually increased until it amounted to 76,900 lbs. Under this load the beam failed by longitudinal shear, which was accompanied by a certain amount of rippling of the fibres on the compression side of the centre, as in Figs. 48, 49.

The maximum skin stress corresponding to the breaking load of 76,900 lbs. was 6135 lbs. per square inch.

The total compression under a load of 41,000 lbs. at the centre was 1.7 in., and taking the effective depth of the beam to be 14.5 ins., the corresponding maximum skin compressive stress is 6495 lbs. per square inch, the corresponding skin tensile stress being 8221 lbs. per square inch.

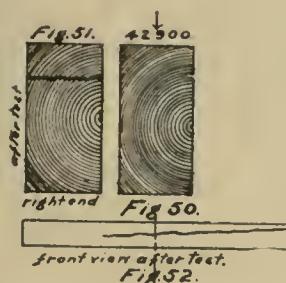
Assuming the ordinary law to hold good for the whole of the effective depth, the maximum skin stress would be 7662 lbs. per square inch.

The coefficient of elasticity, as determined by an increase in the deflection of .16-in. between the loads of 11,000 and 22,000 lbs., is 1,199,741 lbs.; as determined by an increment of the deflection of .33-in. between the loads 10,000 lbs. and 32,000 lbs., it is 1,163,384 lbs.; and as deduced from an increment in the deflection of .29-in., the mean between .285-in. and .295-in., the increments between the loads of 5,000 and 25,000 lbs. and 10,000 and 30,000 lbs. respectively, it is 1,203,500 lbs.

Table II shows the several readings.

The total weight of the beam on Nov. 25th, the date of test, was 331 lbs. 9 ozs., or 32.8 lbs. per cubic foot. After cutting off the ends, the weight of a length of 9 feet was 262 lbs. 5 ozs., or 33.4 lbs. per cubic foot. The total weight of the beam on October 3rd was 339 lbs. 9 ozs.

Beam XXV from Trestle 316. This beam was tested Nov. 28th, 1893, with the annular rings as in Fig. 50, and showing the heart on one of the faces.



It contained one vertical bolt hole, several knots, and many season cracks. The grain was straight.

The load upon the beam was gradually increased until it amounted to 42,900 lbs., when a large splinter broke off on the tension face, and the beam failed by longitudinal shear, as in Figs. 51, 52.

The maximum skin stress corresponding to this breaking load is 4613 lbs. per square inch.

The coefficient of elasticity, as determined by an increment in the deflection of .335-in. between the loads of 4,000-lbs. and 20,000 lbs., is 949,720 lbs.

Table I shows the readings for the several loads.

The total weight of the beam on October 3rd was 422 lbs., or 34.44 lbs. per cubic foot, and on Nov. 28th, the date of test, the weight was 406 lbs., or 33.11 lbs. per cubic foot, showing a loss of weight in the Laboratory at the rate of .237-lbs. per cubic foot per day.

The time occupied by the test was 30 minutes.

The following Table gives a summary of the results obtained for Douglas Fir:—

| BEAM.                           | Dimensions in inches.                  | Weight in lbs. per cubic foot at date of test. | Maximum skin stress in lbs. per sq. in. | Co-efficient of elasticity in lbs. |
|---------------------------------|--|--|---|------------------------------------|
| NEW TIMBER, SPECIALLY SELECTED. |  |  |   |                                    |
| III.                            | $l = 66 \times d = 5.375 \times 4.125$ | 10,441   | 2,178,100                               |                                    |
| XIX.                            | $l = 138 \times 12.1 \times 9.1$       | 9,043  | 1,934,500                               |                                    |
| VII.                            | $l = 69 \times 6 \times 5.8125$        | 8,712  | 2,044,115                               |                                    |
| XV.                             | $l = 198 \times 15 \times 6.125$       | 8,020  | 1,989,400                               |                                    |
| NEW TIMBER, FIRST QUALITY.      |  |  |   |                                    |
| X                               | $l = 198 \times 14.875 \times 6$       | 37.80  | 4,027                                   | 1,629,616                          |
| XI                              | $l = 204 \times 14.875 \times 8.6875$  | 36.99  | 5,698                                   | 1,770,563                          |
| IX                              | $l = 204 \times 14.875 \times 9$       | 35.76  | 7,694                                   | 1,764,939                          |
| VIII                            | $l = 69 \times 5.125 \times 5.5$       | 35.74  | 8,382                                   | 1,584,692                          |
| XVIII                           | $l = 138 \times 17.8 \times 8.76$      | 35.59  | 5,196                                   | 1,329,900                          |
| XVII                            | $l = 138 \times 15.125 \times 9$       | 35.17  | 4,907                                   | 1,259,600                          |
| XX                              | $l = 138 \times 12 \times 8.88$        | 34.92  | 6,559                                   | 1,571,150                          |
| XII                             | $l = 204 \times 14.875 \times 8.8125$  | 34.79  | 7,645                                   | 1,678,300                          |
| XIII                            | $l = 204 \times 14.75 \times 66$       | 34.13  | 6,912                                   | 1,643,193                          |
| XXI                             | $l = 138 \times 8.98 \times 5.95$      | 30.83  | 7,784                                   | 1,588,400                          |
| VI                              | $l = 69 \times 6.125 \times 6$         | 30.23  | 7,116                                   | 1,489,215                          |
| I                               | $l = 96 \times 12.125 \times 9$        |  | 4,897                                   | 1,138,500                          |
| II                              | $l = 66 \times 12.125 \times 5.625$    |  | 4,378                                   | 1,146,900                          |
| V                               | $l = 69 \times 9.125 \times 5$         | 29.18  | 5,869                                   | 946,270                            |
| IV                              | $l = 69 \times 9.125 \times 5$         | 28.27  | 4,156                                   | 926,500                            |
| OLD TIMBER.                     |  |  |   |                                    |
| XXIII                           | $l = 186 \times 14.35 \times 8.78$     | 38.59  | 7,339                                   | 1,878,950                          |
| XXII                            | $l = 162 \times 15.6875 \times 7.75$   | 33.75  | 7,086                                   | 1,665,560                          |
| XXV                             | $l = 144 \times 15.65 \times 8.2$      | 33.11  | 4,613                                   | 949,720                            |
| XXIV                            | $l = 132 \times 16.2 \times 7.75$      | 32.8   | 6,135                                   | 1,201,620                          |

The following data may be adopted in practice:—

In the case of specially selected timber, free from knots, with sound clear and straight grain, and cut out of the log at a distance from the heart:

Average weight in lbs. per cubic foot = 40.

Average co-efficient of elasticity in lbs. per sq. in. = 2,000,000.

Average maximum skin stress in lbs. per square inch = 9000.

Safe working skin stress in lbs. per square inch = 3000-lbs.

In the case of first quality timber, such as is ordinarily found in the market:

Average weight in lbs. per cubic foot = 34.

Average co-efficient of elasticity in lbs. per square inch = 1,430,000.

Average maximum skin stress in lbs. per square inch = 6000.

Safe working skin stress in lbs. per square inch = 2000.

In specifying these data it will be observed that 3 is adopted as the factor of safety. Upon this hypothesis the factor of safety for the stick giving the minimum skin stress in more than 2, and this, in the opinion of the author, is an ample factor for a material which experience and all experiments show, may be strained without danger very nearly up to the point of fracture.

Further, the results obtained in the experiments with the old stringers shew that the strength of the timber had been retained to a very large extent, and that the rotting had not extended to such a depth below the skin as to sensibly affect the efficiency of the sticks, which still possessed ample strength for the work they were designed to do.

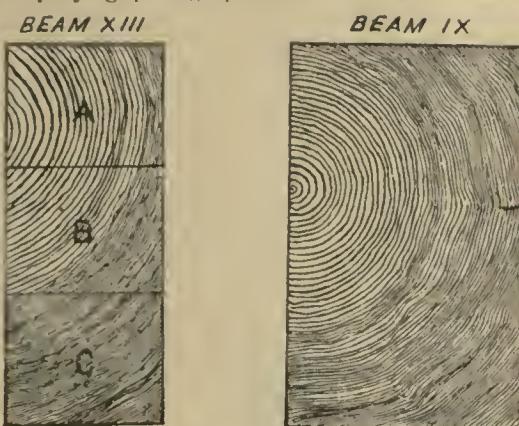
Thus in Beam XXII a diminution in the skin stress of 1058 lbs. per square inch, which is equivalent to a diminution in the effective depth of  $\frac{15.6875 \times 1058}{2 \times 7058} = 1.076$ -ins. would still leave 6000 lbs. per square inch as the skin stress. Thus if the rotting had extended to depth of 1.176 ins., the factor of safety would still remain 3.

If 2 is adopted as the factor of safety, and, in the opinion of the author, 2 is an ample factor for the great majority of cases, the rotting might extend without danger to a depth of 3,398 ins.

In the case of Beam XXV, which is the old stringer giving the least coefficient of strength, namely, 4613 lbs. per square inch, taking 2 as the factor of safety, the effective depth might be diminished by an amount of  $\frac{15.65 \times 613}{2 \times 4613} = 1.04$  ins. and rot might safely extend to this depth.

Again, it will be observed that the skin stress and the elasticity are subject to a wide variation. This variation is due to many causes, of which the most important are the presence of knots, obliquity of grain, and, more than all, the locality in which the timber was grown, the original position of the stick in the log from which it was cut, and the proportion of hard to soft fibre, or of the summer to the spring growth. The tensile shearing and compressive experiments upon specimens cut out of different parts of the same log all shew that the timber near the heart possesses much less strength and stiffness than the timber at a distance from the heart.

The accompanying photograph is given to show the variation of



thickness in the growth rings from the heart outwards, and a careful study of the results obtained up to date would seem to indicate that the best classification defining the strength of the timber would be found by dividing the section of a log into three parts by means of two circles, with the heart as the centre, and by designating the central portion as third quality, the portion between the two circles as second quality, and the outermost portion as first quality.

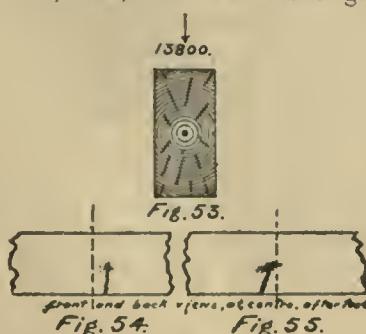
A most interesting paper on the structural characteristics of Douglas Fir from a botanical standpoint was read by Professor Penhallow, F.R.S.C., at the meeting of the Royal Society of Canada in Ottawa, in 1894, in connection with a paper by the author on the strength of the timber.

#### RED PINE.

Beams XXVI to XXXIII were sent to the laboratory *by* Messrs. McLaehlin Bros., of Arnprior.

These beams were not specially selected, but were the ordinary scantlings in the market. They were cut from logs felled in February or March, 1893, in the neighbourhood of the Bonnechère River, Nipissing District, County Renfrew. The logs remained in the water from April until October, when they were sent to the mill, where they were sawn up and piled.

Beam XXVI. This beam was cut from the heart of the tree, and was tested March 13th, 1894, with the annular rings, as in Fig. 53.



The load upon the beam was gradually increased until it amounted to 13,800 lbs., when the beam failed by the crippling of the fibres on the compression face, Figs. 54, 55. The load was still further increased until complete fracture took place by the tearing apart of the fibres on the tension face under a load of 17,170 lbs. The crippling was in line with a knot running through the timber from back to front, as in the Figure.

The maximum skin stress corresponding to the load of 13,800 lbs. is 3937 lbs. per square inch.

The total compression of the timber at the centre was .2-in., so that, taking the effective depth as 13.05, the maximum skin compressive stress would be 3994 lbs. per sq. in., the corresponding skin tensile stress being 4119 lbs. per square inch.

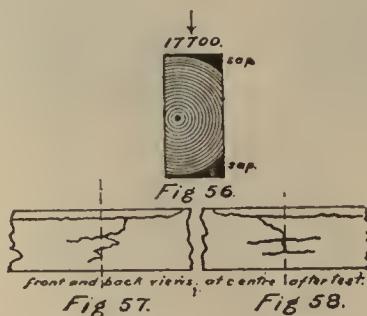
Assuming the ordinary law to hold good for the whole of the effective depth, the maximum skin stress would be 4059 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .885-in. between the loads 1,000 and 8,000 lbs., is 1,235,600 lbs., and as determined by an increment in the deflection of .5-in. between the loads 2,000 and 6,000 lbs., is 1,248,990 lbs.

Table K shows the several readings.

The weight of this beam, on March 10th, was 392 lbs. 2 ozs., or 37.56 lbs. per cubic foot, and on March 13th it was 379 lbs. 4 ozs., or 36.39 lbs. per cubic foot, showing a loss of weight in the laboratory at the rate of .39-lb. per cubic foot per day.

Beam XXVII was tested April 5th, 1894, with the annular rings as in Fig. 56. The beam was cut from the heart of the tree, and the darkened portion in the Figure, was sapwood.



The load upon the beam, was gradually increased until it amounted to 17,700 lbs., when the beam failed by the tearing apart of the fibres on the tension face, Figs. 57, 58, at a resin pocket, the fracture showing a fine resinous surface.

The maximum skin stress corresponding to the breaking load is 5219 lbs. per square inch.

The total compression of the timber at the centre was .34-in., so that taking 12.785 ins. as the effective depth, the maximum skin compressive stress would be 5411 lbs. per square inch, the corresponding skin tensile stress being 5707 lbs. per square inch.

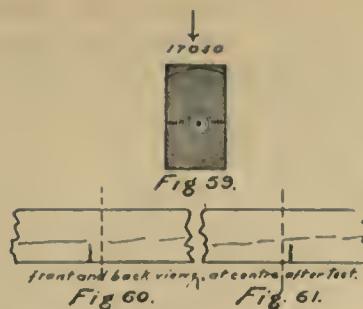
Assuming the ordinary law to hold good for the whole of the effective depth, the maximum skin stress would be 5501 lbs. per square inch.

The co-efficient of elasticity, as deduced from an increment in the deflection of 7-in. between the loads 1500-lbs. and 7500 lbs., is 1,418,500 lbs.

Table K gives the several readings.

The total weight of the beam on March 10th was 46 lbs. 12 ozs., or 41.51 lbs. per cubic foot; the total weight on April 5th, the date of test, was 397 lbs. 4 ozs., or 36.50 lbs. per cubic foot, showing a loss of weight while in the laboratory, at the rate of .192-lbs. per cubic foot per day.

Beam XXVIII. This beam was cut from the heart of the tree, and was tested April 20th, 1894, with the annular rings as shown in Fig. 59.



The load upon the beam was gradually increased until it amounted to 17,050 lbs., when the beam failed by the crippling of the fibres on the compression face, Figs. 60, 61. The load was still increased until under 19,140 lbs., the beam again failed by the tearing apart of the fibres on the tension face.

The maximum skin stress corresponding to the load under which crippling took place is 6752 lbs. per square inch.

The total compression of the beam under a load of 17,050 lbs. was .24-in., so that taking the effective depth to be 11.01 ins., the corresponding maximum skin compressive stress would be 6886 lbs. per square inch, the corresponding skin tensile stress being 7193 lbs. per square inch.

Assuming the usual law to hold good for the whole of the effective depth, the maximum skin stress would be 7050 lbs. per square inch.

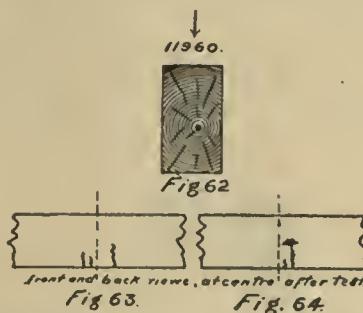
The co-efficient of elasticity, as determined by an increase in the deflection of 1.435 in between the loads of 2000 and 12,000 lbs., is 1,786,000 lbs.; it is 1,858,400 lbs., as determined by an increment in the deflection of .84-in. between the loads 3500 and 9500 lbs., and is 1,681,100 lbs., as determined by an increment in the deflection of 1.135 in. between the loads of 2000 and 10,000 lbs.

Table K shows the several readings.

The test occupied 26 minutes.

The weight of the beam on March 10th was 379 lbs. 10 ozs., or 44.20 lbs. per cubic foot; upon April 20th, the date of test, the weight was 322 lbs. 8 ozs., or 37.55 lbs. per cub. ft., showing a loss of weight at the rate of .1622-lb. per cubic foot per day.

Beam XXIX. This beam was cut from the heart of the tree, and was tested March 13th, 1894, with the annular rings as in Fig. 62



The load upon the beam, was gradually increased until it amounted to 11,960 lbs., when the beam failed by the crippling of the fibres on the compression face, Figs. 63, 64. The load was still further gradually increased to 12,460 lbs., when the beam was completely fractured by the tearing apart of the fibres on the tension face.

The maximum skin stress corresponding to the breaking load of 11,960 lbs. is 4818 lbs. per square inch.

The total compression of the timber at the centre was .15-in., so that taking 11.1-in. as the effective depth, the maximum skin compressive stress would be 4883 lbs. per square inch, the corresponding skin tensile stress being 5016 lbs. per square inch.

Assuming the usual law to hold good for the whole of the effective depth, the maximum skin stress would be 4949 lbs. per square inch.

The co-efficient of elasticity, as determined from an increment of .86-in. in the deflection between the loads of 1000 and 5000 lbs., is

1,210,100 lbs. The co-efficient of elasticity, as deduced from an increment of 1.315-in. in the deflection between the loads of 1000 lbs. and 7000 lbs., is 1,187,000 lbs.

Table L shews the several readings.

The test occupied 27 minutes.

The total weight of the beam was 290 lbs., or 32.89 lbs. per cubic foot on March 10th, and 282 lbs. 6 ozs., or 32.03 lbs. per cubic foot on March 13th, showing a loss of weight in the laboratory at the rate of .2866-lb. per cubic foot per day.



Fig. 65.

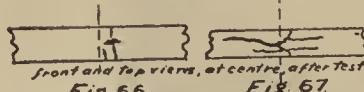


Fig. 66. Fig. 67.

Beam XXX. This beam was tested May 3rd, 1894, with the annular rings, as in Fig. 65. When the beam was placed in position, it showed an upward camber of 24 ins.

The load upon the beam was gradually increased until it amounted to 5700 lbs., when the beam failed by the crippling of the fibres on the compression face, Fig. 66, the crippling extending  $2\frac{1}{2}$  ins. upwards from the skin. The load was still increased, and when it amounted to 6580 lbs., the beam broke right across the tension face about  $2\frac{1}{2}$  inches from the middle of the beam, and vertically above the second line of crippling on the compression side, Fig. 67.

The maximum skin stress corresponding to the breaking load of 5700 lbs. is 4634 lbs. per square inch, and the maximum skin stress corresponding to the load of 6580 lbs. is 5340 lbs. per square inch.

The co-efficient of elasticity is 1,322,000 lbs., as determined by an increment in the deflection of 1.69-in. between the loads of 1000 and 5000 lbs.; it is 1,329,900 lbs., as deduced from an increment in the deflection of .84-in. between the loads of 2000 and 4000 lbs.

Table L shows the several readings.

The weight of this beam on May 4th, the day after the test, was 150 lbs. 11 ozs., or 30.96 lbs. per cubic foot.

Beam XXXI. This beam was tested May 4th, 1894. It was cut from the heart of the tree, and the annular rings were situated as in Fig. 68. Season cracks ran intermittently from end to end of the beam



Fig. 71. Fig. 68.

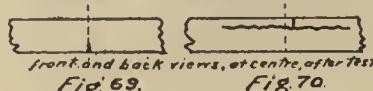


Fig. 69. Fig. 70.

in the neighbourhood of the neutral plane, the cracks extending radially outwards from the heart. The beam was free from knots for a distance of 7 inches on one side and 1 inch on the other, and the grain ran parallel to the axis.

The load upon the beam was gradually increased until it amounted to 6500 lbs., when it failed by a crippling of the fibres on the compression face, Fig. 69. The crippling occurred exactly at the centre and extended 1.5 in. upwards from the skin. The load was then continued, and, when it amounted to 7900 lbs., the beam failed by the tearing apart of the fibres on the tension face, Figs. 70, 71, and a line of crippling on the compression side timber opened upwards for a distance of about 2 ins. or  $3\frac{1}{2}$  ins. The fracture on the tension side took place about  $5\frac{1}{2}$  ins. from the centre, and the timber opened

along the annular rings for a distance of 24 ins. on each side of the centre as in the figure.

The maximum skin stress corresponding to the breaking load of 6500 lbs. is 5442 lbs. per square inch.

The co-efficient of elasticity, as deduced from an increment in the deflection of 1.085 ins. between the loads of 2000-lbs. and 5000 lbs., was 1,618,900 lbs.

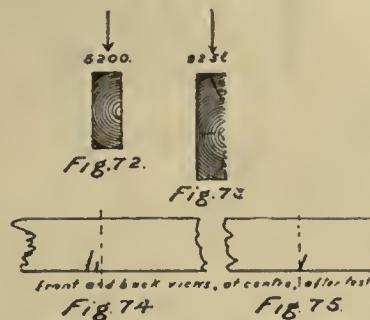
Table L shews the several readings.

This beam when first placed in position, also had a camber of .35-ins. in a central length of 14 ft. 6 ins.

The weight of the beam on May 4th, the date of test, was 165 lbs. 6 ozs., or 34.97 lbs. per cubic foot.

Beams XXXII to XXXV might perhaps more properly be designated 3 ins. planks.

Beam (Plank) XXXII was tested May 7th, 1894. The heart was in one of the faces, and the annular rings were situated as in Fig. 72.



The load upon the beam gradually increased until it amounted to 5200 lbs., when it failed by a crippling of the fibres on the compression side. The crippling occurred about  $1\frac{1}{2}$  ins. away from the centre of the beam and extended upwards about 1.5 ins. The load was still increased, and when it amounted to 5860 lbs., the beam again failed by the tearing apart of the fibres on the tension side. A line of crippling also extended upwards a further distance of about 2 ins., or about  $3\frac{1}{2}$  ins. from the skin.

The maximum skin stress corresponding to the breaking load of 5200 lbs. is 6928 lbs. per square inch.

The co-efficient of elasticity, as deduced from an increment in the deflection of 1.67-ins. between the loads 1000-lbs. and 4000 lbs., is 1,575,200 lbs. per square inch.

Table L shews the several readings.

The weight of this beam on May 7th, the date of test, was 102 lbs., or 31.56 lbs. per cubic foot.

Beam (Plank) XXXIII was tested May 7th, 1894, with the annular rings as shown in Fig. 73.

The load upon the beam was gradually increased to 9250 lbs., when failure took place by the crippling of the fibres on the compression side, Figs. 74, 75. There were two lines of crippling on the front and one at the middle of the beam at the back. The crippling at the back probably occurred first, as the folding of the timber extends across the section of the beam along the central line at the lower edge, but not up to the point where the failure due to compression was apparently the greatest. In the neighbourhood of the crippling in front, the timber was clear, and the grain ran straight and parallel with the axis; at the back there were three knots, which were primarily the cause of the crippling.

When the load on the beam had been increased to 9900 lbs., fracture occurred on the tension side.

The maximum skin stress corresponding to the breaking load of 9250 lbs. is 6554 lbs. per sq. in.

The co-efficient of elasticity, as determined by an increment in the deflection of .76 in. between the loads 2600 and 6200 lbs., is 1,618,000 lbs.

Table M shews the several readings.

The weight of the beam on May 7th, date of test, was 128 lbs. 8 ozs., or 31.87 lbs. per cubic foot.

Beam (Plank) XXXIV. This beam was tested May 8th, 1894, with the annular rings as in Fig. 76.



Fig. 76.



Fig. 77.



Fig. 78.

The load upon the beam was gradually increased until it amounted to 5600 lbs., when the fibres on the compression face crippled to a small extent. On still further increasing the load, the fibres on the compression face were completely crippled, Figs. 77, 78, and fracture also simultaneously occurred on the tension side when the load amounted to 8400 lbs.

The grain of this beam was straight and parallel with the axis, and the timber was apparently free from knots for a distance of about 24 inches on each side of the centre.

The maximum skin stress corresponding to the breaking load of 5600 lbs. is 5079 lbs. per square inch, and the skin stress corresponding to the load of 8400 lbs., which caused the fracture on the tension side, is 7597 lbs. per square inch.

The coefficient of elasticity, as deduced from an increment in the deflection of 1.14 ins. between the loads of 500 and 5600 lbs., was 1,784,800 lbs.

Table M shews the several readings.

The weight of the beam on May 8th, date of test, was 96 lbs. 2 ozs., or 36.59 lbs. per cubic foot.

Beam (Plank) XXXV was tested May 8th, 1894, with the annular rings as in Fig. 79. The heart of the tree was very nearly coincident with the axis of the beam, and the grain ran in the same direction. Season cracks occurred intermittently throughout the beam.



Fig. 79.

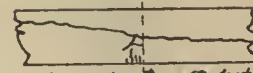


Fig. 80.

The load upon the beam was gradually increased until it amounted to 7600 lbs., when the beam failed by the crippling of the fibres on the compression face, Fig. 80. The load was still increased, and well defined crippling occurred when it amounted to 10,050 lbs. When the load had reached 13,700 lbs. the beam failed by the tearing apart of the fibres on the tension face, Fig. 80.

The maximum skin stress corresponding to the breaking load of 7600 lbs. is 4339 lbs. per square inch.

The coefficient of elasticity, as determined by an increment in the deflection of .92-in. between the loads of 500 and 7600 lbs., is 1,589,250 lbs., and as determined by an increment in the deflection of .025-in. for the corresponding increase of 200 lbs. it is 1,642,900 lbs.

Table M shews the several readings.

The weight of the beam on May 8th, date of test, was 128 lbs. 12 ozs. or 37.69-lbs. per cubic foot.

The following Table gives a summary of the results obtained for Red Pine:—

| BEAM.       | Dimensions in inches.                       | Weight in lbs. per cubic foot at date of test. | Maximum skin stress in lbs. per sq. inch. | Co-efficient of elasticity in lbs. |
|-------------|---|--|---|------------------------------------|
| NEW TIMBER. |   |  |   |                                    |
| XXXV.       | $l = 156 \times d = 11.15 \times b = 3.325$ | 37.69  | 4,339                                     | 1,616,075                          |
| XXVIII.     | $210 \times 11.25 \times 6.34375$           | 37.55  | 6,752                                     | 1,802,633                          |
| XXXIV.      | $156 \times 9.125 \times 3.125$             | 36.59  | 5,079                                     | 1,784,800                          |
| XXVII.      | $210 \times 13.125 \times 6.1875$           | 36.50  | 5,219                                     | 1,418,500                          |
| XXVI.       | $210 \times 13.25 \times 6.375$             | 36.39  | 3,937                                     | 1,241,950                          |
| XXXI.       | $174 \times 7.125 \times 6.21875$           | 34.97  | 5,442                                     | 1,618,900                          |
| XXIX.       | $210 \times 11.25 \times 6.25$              | 32.03  | 4,818                                     | 1,198,550                          |
| XXXIII.     | $180 \times 11.125 \times 3.1$              | 31.87  | 6,554                                     | 1,618,000                          |
| XXXII.      | $180 \times 8.125 \times 3.1$               | 31.56  | 6,928                                     | 1,575,200                          |
| XXX.        | $174 \times 7.25 \times 6.1875$             | 30.96  | 4,634                                     | 1,325,950                          |

Hence,

The average weight in lbs. per cubic foot = 34.61.

" co-efficient of elasticity in lbs. per sq. in. = 1,520,056.

" maximum skin stress " " = 5370.

If, however, the plank results are omitted,

The average weight in lbs. per cubic foot = 34.78.

" co-efficient of elasticity in lbs. per sq. in. = 1,434,747.

" maximum skin stress " " = 5137.

In general, the following data may be adopted in practice:—

The average weight in lbs. per cubic foot = 34.6.

" co-efficient of elasticity in lbs. per sq. in. = 1,430,000.

" maximum skin stress " " = 5,100.

" safe working skin stress " " = 1,700,

3 being a factor of safety.

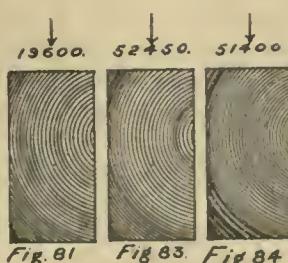
In the accounts of the several beams it will be observed that the failures are almost invariably due to the crippling of the material on the side in compression, indicating that the tensile strength of the timber exceeds its compressive strength, and this was subsequently verified by the direct tension and compression experiments.

### WHITE PINE.

Beams XXXVI and XXXVII are two pieces cut out of one large piece of square pine, made and taken out in the Gatineau Valley, Ottawa County. The timber was brought down via the Gatineau and Ottawa Rivers to Montreal, and remained in the water until late in the fall of 1892, when it was piled on the land for winter sawing.

This timber was purchased from Messrs. J. & B. Grier.

Beam XXXVI was tested February 16th, 1893, with the annular rings as in Fig. 81.



The load upon the beam was gradually increased until it amounted to 19,600 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 2993 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of 1.12 ins. between the loads of 5000 and 10,000 lbs., is 503,440 lbs.; as deduced from an increment in the deflection of .84-in. between the loads of 5000 and 12,500 lbs., is 463,768 lbs., and as deduced from an increment in the deflection of 2.13 ins. between the loads of 5000 and 15,000 lbs., is 534,169 lbs.

Table N shows the several readings.

The weight of this beam per cubic foot on Feb. 16th was 37.25 lbs., and on March 14th, 34.78 lbs., showing a loss of weight at the rate of .095-lb. per cubic foot per day.

Beam XXXVII was tested on February 24th, 1893, with the annular rings as in Fig. 82.



Fig. 82. Fig. 85. Fig. 86.

The load was gradually increased until it amounted to 24,000 lbs., when the beam failed by the tearing apart of the fibres on the tension face.

The maximum skin stress corresponding to this load is 3555 lbs. per square inch.

Beams XXXVIII and XXXIX were the two ends of Beam XXXVI which was tested February 16th, 1893, the central portion containing the fracture having been cut out.

Beam XXXVIII was tested on March 14th, with the annular rings as in Fig. 83.

The load on the beam was gradually increased until it amounted to 52,450 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 3075 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .37-in. between the loads of 10,000 and 25,000 lbs., is 622,640 lbs.

Table N shows the several readings.

Beam XXXIX was tested with the annular rings as in Fig. 84.

The load was gradually increased until it amounted to 51,400 lbs., when the beam failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 2696 lbs. per square inch.

The co-efficient of elasticity, as determined from an increment in the deflection of .175-in. between the loads of 10,000 and 25,000 lbs., is 433,250 lbs.

Table N shows the several readings.

Beams XL and XLI are the two ends of Beam XXXVII which was tested on Feb. 24th, 1893, the central portion of the beam containing the fracture having been cut out.

Beam XL was tested on March 17th with the annular rings as in Fig. 85. The load was gradually increased until it amounted to 53,650 lbs., when the beam failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 3311 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .19-in. between the loads of 12,000 and 26,000 lbs., is 693,090 lbs.

Table N shows the several readings.

The weight of the beam per cubic foot on the day of the test was 36.13 lbs.

Beam XLII was tested on March 17th, 1893, with the annular rings as in Fig. 86. The load upon the beam was gradually increased until it amounted to 40,500 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 2500 lbs. per square inch.

The coefficient of elasticity, as deduced from an increment in the deflection of .19-in. between the loads of 10,000 lbs. and 22,000 lbs., is 519,820 lbs. per square inch.

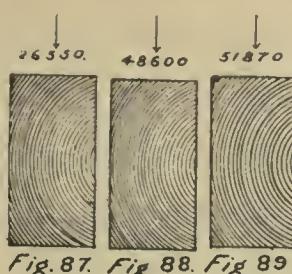
Table N shows the several readings.

The weight of the beam on the day of test was 36.13 lbs. per cubic foot.

Beams, XLII and XLVI were cut out of one large piece of square pine made on the Petewawa, a tributary of the Ottawa, in 1888. The piece was driven over 1300 miles, and lay in water for four years until it was taken out in the fall of 1892 and piled for winter sawing.

This timber was purchased from Messrs. Shearer & Brown.

Beam XLII was tested March 8th, 1893, with the annular rings as in Fig. 87.



The load on the beam was gradually increased until it amounted to 26,350 lbs., when the beam failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 3815 lbs. per square inch.

The coefficient of elasticity, as determined by an increment in the deflection of 1.22 ins. between the loads of 2500 lbs. and 13,000 lbs., is 979,220 lbs.

Table O shows the several readings.

The weight of the beam per cubic foot at the date of test was 41.49 lbs.

Beams XLIII and XLIV are the two ends of Beam XLII tested March 8th, the central portion of the beam containing the fracture having been cut out.

Beam XLIII was tested March 31st, with the annular rings as in Fig. 88.

The load was gradually increased until it amounted to 48,600 lbs., when the beam failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 3000 lbs. per square inch.

The coefficient of elasticity, as determined by an increase in the deflection of .19-in. between the loads of 10,000 and 25,000 lbs., is 649,780 lbs. per square inch.

Table O shows the several readings.

Beam XLIV was tested March 31st, 1893, with the annular rings as in Fig. 89.

The load upon the beam was gradually increased until it amounted to 51,870 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 3148 lbs. per square inch.

The coefficient of elasticity, as determined by an increment in the deflection of .19-in. between the loads of 1000 and 25,000 lbs., is 649,780 lbs. per square inch, the same coefficient as in beam XLIII.

Table O shows the several readings.

Beam XLV was tested March 11th, 1893, with the annular rings as in Fig. 90.

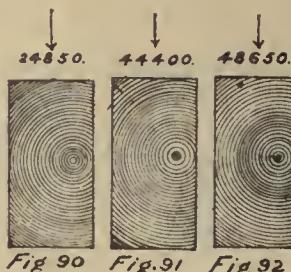


Fig. 90 Fig. 91 Fig. 92

The load upon the beam was gradually increased until it amounted to 24,850 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 3681 lbs. per square inch.

The co-efficient of elasticity, as determined from an increment in the deflection of .81-in. between the loads of 2500 and 12,000 lbs., is 956,540 lbs.

Table P shows the several readings.

Beams XLVI and XLVII are the two ends of Beam XLV, tested on March 11th, 1893, the central portion containing the fracture having been cut out.

Beam XLVI was tested March 30th, 1893, with the annular rings as in Fig. 91.

The load upon the beam was gradually increased until it amounted to 44,400 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 2740 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .23-in. between the loads of 10,000 and 25,000 lbs., is 536,770 lbs.

Table P shows the several readings.

Beam XLVII was tested March 30th, 1893, with the annular rings as in Fig. 92.

The load upon the beam was gradually increased until it amounted to 48,650 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 3003 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .2-in. between the loads 10,000 and 25,000 lbs., is 617,283 lbs.

Table P shows the several readings.

Beams XLVIII to L were sent to the laboratory by Mr. P. A. Peterson. These beams were purchased from the Pembroke Lumber Company, and are supposed to have been similar in quality to the timber used on the Pembroke section of the Canadian Pacific Railway.

Beam XLVIII was tested March 1st, 1894, with the annular rings as in Fig. 93. The darkened portion, Fig. 96, represents sapwood.

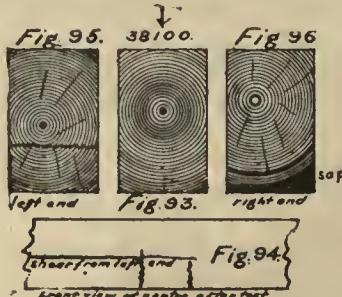


Fig. 94  
cheer from left end front view of eagle after test

The load upon the beam was gradually increased until it amounted to 38,100 lbs., when the beam failed by the crippling of the material at the support on the compression side, Fig. 94. The load was still

gradually increased until it amounted to 47,960 lbs., when a complete fracture took place by the tearing apart of the fibres on the tension side at the centre, and simultaneously by a longitudinal shearing throughout one-half of the length of the beam, as in Figs. 94, 95.

The maximum skin stress corresponding to the breaking load of 38,100 lbs. is 3991 lbs. per square inch; the maximum skin stress corresponding to the load of 47,960 lbs. is 5017 lbs. per square inch.

The total compression of the timber at the centre was .93-in., so that, taking the effective depth to be 14.3875 ins., the maximum compressive skin stress at the support would be 4161 lbs. per square inch, the corresponding maximum tensile skin stress being 4652 lbs. per square inch.

Assuming the usual law to hold good for the whole of the effective depth, the maximum skin stress would be 4447 lbs. per square inch.

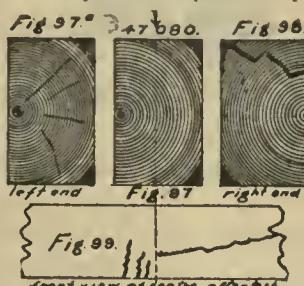
The coefficient of elasticity, as determined by an increment in the deflection of .375-in., between the loads of 2000 lbs. and 19,000 lbs., is 1,164,700 lbs.

Table Q gives the several readings.

The total weight of the beam on March 1st, the date of test, was 524 lbs. 10 ozs., or 41.08 lbs. per cubic foot, and on February 1st the weight was 597 lbs., or 46.73 lbs. per cubic foot, showing a loss of weight at the rate of .209-lb. per cubic foot per day.

The time occupied by the test was 48 minutes.

Beam XLIX was tested March 2nd, 1894, with the annular rings as in Fig. 97. The darkened portions represent sapwood.



The load upon the beam was gradually increased until it amounted to 47,080 lbs., when the beam failed by the tearing apart of the fibres on the tension side, accompanied simultaneously by a longitudinal shear and a crimping of the material in the compression side, Figs. 98, 99.

The maximum skin stress corresponding to the breaking load is 4936 lbs. per square inch.

The total compression of the material at the centre was 2.8 ins., so that taking 13.095 ins. as the effective depth, the maximum skin compressive stress would be 5156 lbs. per square inch, and the corresponding skin tensile stress would be 7353 lbs. per square inch.

Assuming the usual law to hold good for the whole of the effective depth, 6835 lbs. per square inch would be the maximum skin stress.

The coefficient of elasticity, as determined by an increment of .435 in., between the loads of 3000 and 21,000 lbs., is 1,052,600 lbs.

Table Q shows the several readings.

The weight of the beam was 525 lbs. 12 ozs., or 41.33 lbs. per cubic foot February 1st, and 473 lbs. 12 ozs., or 37.24 lbs. per cubic foot on March 2nd, showing a loss of weight at the rate of .141-lbs. per cubic foot per day.

The time occupied by the test was fifty minutes.

Beam L was tested March 10th, 1894, with the annular rings as in Fig. 100.



The load upon the beam was gradually increased until it amounted to 32,200 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 4370 lbs. per square inch.

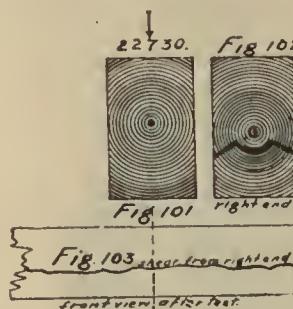
The co-efficient of elasticity, as deduced from an increment in the deflection of .805-in., between the loads of 1000 and 19,000 lbs., is 1,184,240 lbs.

Table Q shows the several readings.

The weight of the beam was 509 lbs. 12 ozs. or 33.64 lbs. per cubic foot, on March 10th, the date of test, and 575 lbs. 8 ozs., or 37.25 lbs. per cubic foot, on February 1st, showing a loss of weight at the rate of .0975-lb. per cubic foot per day.

#### OLD WHITE PINE.

Beams LI to LIII are three old white pine stringers sent to the laboratory by Mr. P. A. Peterson. These stringers had been in service since 1885, *i.e.*, for about eight years; they were removed from the trestles during the summer of 1892.



Beam LI was tested December 1st, 1893, with the annular rings as in Fig. 101.

The load upon the beam was gradually increased until it amounted to 22,730 lbs. when the beam failed by shearing, longitudinally as in Figs. 102, 103, the distance between the portions of the beam above and below the plane of shear being  $\frac{1}{4}$  in.

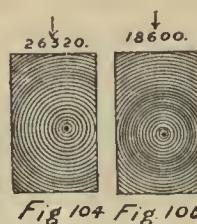
The maximum skin stress corresponding to this load is 3212 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .55-in., between the loads of 2500 lbs. and 12,000 lbs. is 982,480 lbs.

Table R shows the several readings.

The total weight of the beam on December 1st, date of test, was 445 lbs., or 28.3 lbs. per cubic foot. The weight of a length of 14 ft.  $1\frac{3}{4}$  ins. was 376 lbs., or 28.12 lbs. per cubic foot on December 2nd, and 367 lbs. 5 ozs., or 27.47 lbs. per cubic foot on December 8th, showing a loss of weight at the rate of .1083-lb. per cubic foot per day.

Beam LII was tested December 9th, 1893, with the annular rings as in Fig. 104.



The load upon the beam was gradually increased until it amounted to 26,320 lbs., when the beam failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this breaking load is 3589 lbs. per square inch.

The total compression of the material at the support was .37-in., so that, taking 14.85 ins. as the effective depth, the maximum skin com-

pressive stress is 3671 lb. per square inch, the corresponding maximum tensile stress being 3863-lb. per square inch. Assuming the usual law to hold good for the whole of the depth, the maximum skin stress per square inch would be 3774 lbs.

The co-efficient of elasticity, as determined from an increment in the deflection of .635-in. between the loads of 2500 lbs. and 14,500 lbs., is 929,690 lbs.

Table R shows the several readings.

The weight of the beam on November 29th was 430 lbs., or 28.71 lbs. per cubic foot, and on December 9th, the date of test, the weight was 415 lbs. 6½ ozs., or 26.08 lbs. per cubic foot, showing a loss of weight at the rate of .263-lb. per cubic foot per day.

Beam LIII was tested December 9th, 1893, with the annular rings as in Fig. 105.

The beam was a poor specimen, being full of knots and season cracks, and partly decayed. The grain on the top was parallel, while on the sides it was somewhat oblique.

The load upon the beam was gradually increased until it amounted to 18,600 lbs., when it failed by the tearing apart of the fibres on the tension side.

The maximum skin stress due to this breaking load is 2495 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .55-in. between the loads of 1500 lbs. and 10,000 lbs., is 650,930 lbs.

Table R shows the several readings.

The weight of the beam was 450 lbs. 12 ozs., or 29.02 lbs. per cubic foot on Nov. 9th, and 438 lbs. 13 ozs., or 28.25 lbs. per cubic foot on Dec. 8th, showing a loss of weight at the rate of .0855 lb. per cubic foot per day.

The time occupied by the test was 20 minutes

The following Table gives the summary of the results obtained for White Pine :—

N<sub>EW</sub> T<sub>I</sub>M<sub>B</sub>R.

| BEAMS.   | Dimensions in inches. |           |          | Weight in lbs. per cubic foot at date of test. | Maximum skin stress in lbs. per sq. in. | Co-efficient of Elasticity in lbs. |
|----------|-----------------------|-----------|----------|--|---|------------------------------------|
|          | <i>t</i>              | <i>d</i>  | <i>b</i> |  |   |                                    |
| XLI.     | 288                   | × 18      | × 9      | 41.49  | 3,815                                   | 979,220                            |
| XLV.     | 288                   | × 18      | × 9      | 41.49  | 3,681                                   | 956,540                            |
| XLVIII.  | 150                   | × 15.1875 | × 9.375  | 41.08  | 3,991                                   | 1,164,700                          |
| XLVI.    | 120                   | × 18      | × 9      | 39.53  | 2,740                                   | 536,770                            |
| XLVII.   | 120                   | × 18      | × 9      | 39.40  | 3,003                                   | 617,283                            |
| XLIII.   | 120                   | × 18      | × 9      | 39.50  | 3,000                                   | 649,780                            |
| XLIV.    | 120                   | × 18      | × 9      | 39.40  | 3,148                                   | 649,780                            |
| XXXVI.   | 288                   | × 18      | × 9      | 37.25  | 2,993                                   | 500,000                            |
| XLIX.    | 150                   | × 15.375  | × 9.125  | 37.24  | 4,936                                   | 1,052,600                          |
| XXXVII.  | 288                   | × 18      | × 9      | 36.43  | 3,555                                   |                                    |
| XL.      | 120                   | × 18      | × 9      | 36.13  | 3,311                                   | 693,090                            |
| XLI.     | 120                   | × 18      | × 9      | 36.13  | 2,500                                   | 519,820                            |
| XXXVIII. | 114                   | × 18      | × 9      | 34.78  | 3,075                                   | 622,640                            |
| XXXIX.   | 102                   | × 18      | × 9      | 34.78  | 2,696                                   | 433,250                            |
| L.       | 186                   | × 15      | × 9.0625 | 33.64  | 4,370                                   | 1,184,240                          |

O<sub>L</sub>D T<sub>I</sub>M<sub>B</sub>R.

|       |     |         |        |       |       |         |
|-------|-----|---------|--------|-------|-------|---------|
| LIII. | 180 | × 15    | × 9.05 | 28.25 | 2,495 | 650,930 |
| LI.   | 192 | × 15.12 | × 9    | 28.3  | 3,212 | 982,480 |
| LII.  | 180 | × 14.85 | × 9.05 | 26.08 | 3,589 | 929,690 |

Hence, for the new timber,

The average weight in lbs. per cubic foot = 37.88.

" co-efficient of elasticity in lbs. per sq. in. = 754,265.

" maximum skin stress " " " = 3388.

The following data are suggested for practice :—

The average weight in lbs. per cubic foot = 37.8.

" co-efficient of elasticity in lbs. per sq. in. = 754,000.

" maximum skin stress " " = 3,300.

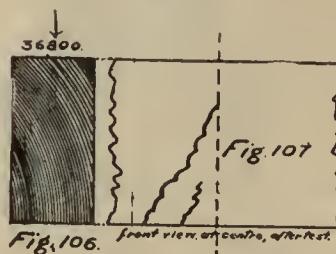
" safe working skin stress in lbs. per sq. in., 3 being at factor of safety = 1100.

Further experiments will probably show that these data require some modification. In fact, the actual skin stress and co-efficients of elasticity are certainly greater than those given in the preceding table, which have been calculated on the assumption that the amount of the compression at the central support is sufficiently small to be disregarded, but it has been shewn, as for example, in the case of Beam XLIX, that the skin stresses are largely affected by this compression. The co-efficients of elasticity are also necessarily increased by the diminution in the effective depth. Similar remarks apply to the other timbers.

From the experiments with the old White Pine stringers, it might be inferred that these timbers have lost considerably in weight, but that they have in a great degree retained their strength and stiffness. Other old Timbers will require to be tested, however, before any definite statement can be made on the subject.

#### NEW SPRUCE BEAMS.

Beam LIV was tested Nov. 2nd, 1893, with the annular rings as in Fig. 106.



This stick was sent to the laboratory by Mr. T. J. Claxton. It was cut out of a tree felled near the Skeena River, British Columbia, on the Pacific Coast, about six hundred miles north of Victoria. The log was felled in Dec., 1892, or January, 1893, and was over 100 ft. in length, squared 36 ins. at the small end, and would have provided from 12,000 to 15,000 of market lumber.

The beam in question was sawn from the log in June, 1893, and was shipped by steamer at the end of June from the town of Claxton, situated at the mouth of the Skeena River, where the mills are located. At Victoria the beam was transhipped and brought down in August via the C.P.R. to Montreal. It was delivered at the laboratory early in September.

It might, perhaps, be of interest to note that the cost of freight for this beam from Claxton to Victoria was \$4.00; from Victoria to Vancouver \$2.00; from Vancouver to Montreal \$46.00; and the cartage to the University \$4.00, making a total cost of freight of \$56.00.

It is said that the spruce from the Skeena District is of a specially fine quality, having a clear straight grain, and possessing a large amount of toughness.

The load upon the beam was gradually increased until it amounted to 36,800 lbs., when the beam failed by the crippling of the fibres on the compression side, Fig. 107.

The maximum skin stress corresponding to this breaking load 5908 lbs. per square inch.

The total compression of the material at the central support was .5-in., so that taking the effective depth as 17 ins., the maximum skin compressive stress is 5941 lbs. per square inch, the corresponding skin tensile stress being 6301 lbs. per square inch.

If it is assumed that the usual law holds good for the whole of the effective depth of 17 ins., the maximum skin stress is 6260 lbs. per square inch.

The co-efficient of elasticity, as deduced from an increment in the

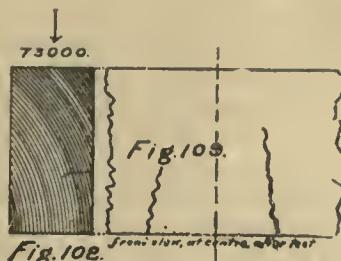
deflection of 1.15 ins. between the loads of 1000 and 15,000 lbs., is 1,528,499 lbs.

Table S shows the several readings.

The weight of the beam on Oct. 3rd was 751 lbs. 6 ozs., or 27.206 lbs. per cubic foot, and on Nov. 3rd, the date of test, it weighed 735 lbs.  $2\frac{1}{2}$  ozs., or 26.614 lbs. per cubic foot, showing a loss while in the laboratory at the rate of .019 lbs. per cubic foot per day.

Beams LV and LVI are the ends of Beam LIV, the central portion containing the fracture having been cut out.

Beam LV was tested Nov. 3rd, 1893, with the annular rings as in Fig. 108.



The load was gradually increased until it amounted to 73,000 lbs., when it failed by the crippling of the fibres on the compression side Fig. 109.

The maximum skin stress corresponding to this load is 4839 lbs. per square inch.

The maximum compression of the material at the central support was 2 ins., so that taking 15.5 ins. as the effective depth, the maximum compressive skin stress is 5123 lbs. per square inch, the corresponding tensile skin stress being 6641 lbs. per square inch.

If it is assumed that the usual law holds good for the whole of the effective depth, the maximum skin stress becomes 6176 lbs.

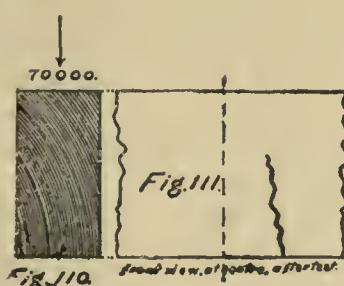
As soon as the beam was relieved of load, the amount of compression at the support was immediately diminished by .9-in., and at the end of thirteen days the amount of compression was .82 in.

The co-efficient of elasticity, as determined by an increment in the deflection of .17-in., between the loads of 3000 lbs. and 10,000 lbs., is 1,070,950 lbs.

Table T shows the several readings.

The weight of the beam on Nov. 3rd, date of test, was 26.614 lbs. per cubic foot

Beam LVI was tested Nov. 4th, 1893, with the annular rings as in Fig. 110.



The load was gradually increased until it amounted to 70,000 lbs., when it failed by the crippling of the fibres on the compression side Fig. 111.

The maximum skin stress corresponding to this breaking load is 4614-lbs. per square inch.

The maximum compression at the centre of support was 1.9 ins., so that taking 15.6 ins. as the effective depth, the maximum compressive skin stress is 4916 lbs. per square inch, the corresponding tensile skin stress being 6280 lbs. per square inch.

If it is assumed that the usual law holds good for the whole of the effective depth, then the maximum skin stress becomes 5806 lbs. per square inch.

Ten days after this beam had been relieved of load, the amount of

the compression of the timber at the centre of support was diminished to .77-in.

The coefficient of elasticity, as determined by an increment in the deflection of .18-in. between the loads of 10,000 lbs. and 30,000 lbs., is 1,011,450 lbs.

Table T shows the several readings.

The weight of this beam on Nov. 3rd was 26.614 lbs. per cubic foot.

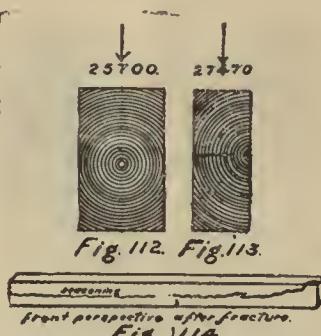
#### OLD SPRUCE.

Beams LVII-LIX were three spruce stringers sent to the laboratory by Mr. P. A. Peterson.

Beams LVII and LVIII were cut at Galbraith's Mill, three miles from Sherbrooke, in 1886, and grew near the same place. They were used in the construction of the bridge near Lennoxville in the winter of 1886-87, and had been in service until the summer of 1894, or for a period of about eight years.

Beam LIX was taken out of Bridge E 61 at Roxton Falls during the summer of 1894, and had been in service since 1885, *i.e.*, for about eight years. This stringer was purchased by Bridge-master MacFarlane, and no further information has been obtained as to its history. The stringer was boxed  $\frac{1}{2}$ -in. at the ends on the bearings, and several season cracks were shown on the surface.

Beam LVII was tested on the 21st April with the annular rings as in Fig. 112.



The load upon the beam was gradually increased until it amounted to 25,700 lbs., when the beam failed by shearing longitudinally along the surface of a season crack, the distance between the portions above and below the plane of shear at the end being  $\frac{3}{8}$ -in.

Immediately after the fracture the jockey weight was run back until the lever again floated, the load upon the beam being 21,000 lbs. This load was then gradually increased until it amounted to 24,700 lbs., when failure occurred by the tearing apart of the fibres on the tension side and by a further ripping of the fibres on the compression side. The lap at the end of the plane of shear was also increased to  $\frac{5}{8}$ -in.

The maximum skin stress corresponding to the breaking load of 25,700 lbs. is 3459 lbs. per square inch.

The maximum compression of the material at the support was .31-in., so that taking the effective depth to be 14.69 ins., the maximum compressive skin stress is 3526 lbs. per square inch, the corresponding tensile skin stress being 3678 lbs. per square inch.

If it is assumed that the usual law holds good for the whole of the effective depth, then the maximum skin stress becomes 3607 lbs. per square inch.

The coefficient of elasticity, as determined by an increment in the deflection of .7-in. between the loads of 1500 and 12,500 lbs., is 1,123,400 lbs.

Table U shows the several readings.

The weight of this beam on April 10th was 502 lbs., or 33.82 lbs. per cubic foot; its weight on April 21st, date of test, was 491 lbs. 4 ozs., or 33.09 lbs. per cubic foot, showing a loss of weight at the rate of .0645 lbs. per cubic foot per day.

Beam LVIII was tested May 1st, 1894, with the annular rings as in Fig. 113. Season cracks ran intermittently from end to end of the beam.

The load upon this beam was gradually increased until it amounted to 27,470 lbs. Under this load the beam failed by shearing longitudinally along a season crack, as shown in Fig. 114, with a partial tension fracture near the end of the beam. The season crack for a distance of about 3 ft. from the centre of the beam appears weathered through the entire thickness of the beam.

Previously, however, to this longitudinal shear, the beam had evidently failed by the crippling of the material, Fig. 114, on the compression side along a line near the centre of the beam where the timber was apparently free from knots and where the fibres were parallel with the axis.

The maximum skin stress corresponding to the load of 27,470 lbs. is 5709 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .575-lbs. between the loads of 2000 and 12,000 lbs., is 1,316,900 lbs.

Table U shows the several readings.

The weight of the beam on March 10th was 267 lbs. 1 oz., or 27.36 lbs. per cubic foot, and its weight on May 2nd was 258 lbs. 6 ozs., or 26.47 lbs. per cubic foot, showing a loss of weight while in the laboratory at the rate of .0168 lb. per cubic foot per day.

Beam LIX was tested June 2nd, 1894, with the annular rings as in Fig. 115.

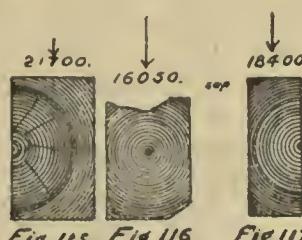


Fig. 115. Fig. 116 Fig. 117.

The load was gradually increased until it amounted to 21,700 lbs., when the beam failed by the tearing apart of the fibres on the tension side.

The maximum skin stress corresponding to this load is 2963 lbs. per square inch.

The maximum compression at the centre was .7-in., so that taking 14.3 ins. as the effective depth, the maximum compressive skin stress is 3079 lbs. per square inch, the corresponding tensile skin stress being 3396 lbs. per square inch.

If it is assumed that the usual law holds good for the whole of the effective depth, then the maximum skin stress is 3261 lbs. per sq. in.

The co-efficient of elasticity, as determined by an increment in the deflection of .43-in. between the loads of 2000 lbs. and 10,000 lbs., is 905,601 lbs.

Table U shows the several readings.

The weight of the beam on June 1st was 445 lbs. 13 ozs., or 30.12 lbs. per cubic foot. Its weight on June 8th was 440 lbs., or 29.72 lbs. per cubic foot, showing a loss of weight at the rate of .0571-lb. per cubic foot per day.

Beams LX and XLI are two old spruce stringers sent to the laboratory by Mr. P. A. Peterson.

They had been in use in Culvert E 39 on the north division of the South Eastern Railway,  $1\frac{1}{2}$  miles north of Waterloo Station, since Oct., 1891, or for about three years.

These timbers were cut and sawn at Keene & Company's mills at the boundary east of Megantic.

Beam LX was tested on Nov. 10th, 1894, with the annular rings as in Fig. 116.

The upper portion of the stringer, *i.e.*, the part in tension, was partially rotten to a depth of about 1-in., and the effective depth at the centre of the beam did not exceed  $11\frac{1}{2}$  ins. The remainder of the section at the centre was in a perfectly sound and good condition.

The load upon the beam was gradually increased until it amounted

to 16,050 lbs., when it failed by the tearing apart of the fibres on the tensile side. The load was still increased, and a more complete fracture occurred under a load of 21,240 lbs. Immediately after this second fracture the jockey weight was run back until the lever again floated, when the load was 15,900 lbs. The load was again gradually increased until it amounted to 18,800 lbs., when fracture again occurred.

The maximum skin stress corresponding to the breaking load of 16,050 lbs. is 2934 lbs.

The maximum compression of the material at the centre was .25-in., so that taking the effective depth to be 11. ins., the maximum compressive skin stress is 3043 lbs. per square inch, and the corresponding tensile skin stress is 3184 lbs. per square inch.

If it is assumed that the usual law holds good for the whole of the effective depth, the maximum skin stress becomes 3118 lbs. per square inch.

The co-efficient of elasticity, as determined by an increment in the deflection of .390-in. between the loads of 2000 and 12,000 lbs., is 1,352,250 lbs. per square inch.

Table V gives the several readings.

The weight of this beam on Nov. 10th, date of test, was 255 lbs. 12½ ozs., or 27.26 lbs. per cubic foot.

Beam LXI was tested Nov. 17th, 1894, with the annular rings as in Fig. 117. There were season cracks from end to end on the front face and numerous knots of medium and small size on the sides. The darkened portion indicates sapwood.

The load upon the beam was gradually increased until it amounted to 18,400 lbs., when the beam failed by the tearing apart of the fibres on the tension face.

The maximum skin stress corresponding to this load is 4309 lbs. per square inch.

The maximum compression of the material at the centre was .21 in., so that taking the effective depth to be 14.29 ins., the maximum skin compressive stress is 4432 lbs. per square inch, the corresponding tensile skin stress being 4565 lbs. per square inch.

If it is assumed that the usual law holds good for the whole of the effective depth, the maximum skin stress becomes 4502 lbs. per square inch.

The co-efficient of elasticity, as determined from an increment of .6-in. in the deflection between the loads of 1000 lbs. and 9000 lbs., is 1,250,850 lbs.

The weight of this beam on Nov. 17th, date of test, was 267 lbs., or 28.85 lbs. per cubic foot.

The following Table gives a summary of the results obtained for Spruce:—

#### NEW TIMBER.

| BEAM. | Dimensions in inches. |          |          | Weight in lbs. per cubic foot at date of test. | Maximum skin stress in lbs. per sq. in. | Co-efficient of Elasticity in lbs. |
|-------|-----------------------|----------|----------|--|---|------------------------------------|
|       | <i>l</i>              | <i>d</i> | <i>b</i> |  |   |                                    |
| LIV.  | 288                   | × 17.5   | × 8.875  | 26.614   | 5,908                                   | 1,528,499                          |
| LV.   | 120                   | × 17.5   | × 8.875  | 26.614   | 4,839                                   | 1,070,950                          |
| LVI.  | 120                   | × 17.5   | × 9.975  | 26.614   | 4,614                                   | 1,011,450                          |

#### OLD TIMBER.

|        |     |         |         |       |       |           |
|--------|-----|---------|---------|-------|-------|-----------|
| LVII.  | 180 | × 15    | × 9     | 33.09 | 3,459 | 1,123,400 |
| LIX.   | 180 | × 15    | × 9     | 30.12 | 2,963 | 905,601   |
| LXI.   | 186 | × 14.5  | × 5.625 | 28.85 | 4,309 | 1,250,850 |
| LX.    | 138 | × 11.25 | × 8.875 | 27.26 | 2,934 | 1,352,250 |
| LVIII. | 180 | × 14.75 | × 6     | 26.47 | 5,709 | 1,316,900 |

Beams LV and LVI were cut out of Beam LIV as already described. The wide variation in the value of the skin-stress and of the coefficient of elasticity is undoubtedly due to the fact that the amount of the compression at the central support has been disregarded in the calculations. If this compression is taken into account, and if it is assumed that the ordinary theory of flexure holds good for the whole of the effective depth, it has been shewn that the skin-stresses in lbs. per sq. in. become 6260 for Beam LIV, 6176 for Beam LV, and 5806 for Beam LVI, the variation in the magnitude of the stresses being comparatively small.

Further experiments will be made with new spruce beams.

The old spruce stringers were found to possess ample strength and stiffness for the work they were designed to do. The experiments gave :—

29.15-lbs. as the average weight per cubic foot.  
1,189,800 "                  "     co-efficient of elasticity.  
3875 "                  "     maximum skin-stress per sq. in.

The following Tables A to V give the end deflections and in some cases the deflections at points dividing the beam into four, six, or eight equal parts, the distance of these points from the ends being stated at the heads of the columns.

Tables A to I show the deflections in inches of Canadian New Douglas Fir Beams (I to XXV) under gradually increased loads.

TABLE A.

Deflections of Beam I at ends.

| Loads<br>in lbs. | Deflec-<br>tion. |
|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 2,000            | .02              | 9,000            | .095             | 16,000           | .18              | 23,000           | .27              | 30,000           | .39              |
| 2,500            | .03              | 9,500            | .10              | 16,500           | .19              | 23,500           | .28              | 30,500           | .40              |
| 3,000            | .03              | 10,000           | .11              | 17,000           | .195             | 24,000           | .285             | 31,000           | .41              |
| 3,500            | .035             | 10,500           | .115             | 17,500           | .20              | 24,500           | .295             | 31,500           | .42              |
| 4,000            | .04              | 11,000           | .12              | 18,000           | .205             | 25,000           | .30              | 32,000           | .43              |
| 4,500            | .045             | 11,500           | .125             | 18,500           | .21              | 25,500           | .31              | 32,500           | .445             |
| 5,000            | .05              | 12,000           | .13              | 19,000           | .22              | 26,000           | .315             | 33,000           | .46              |
| 5,500            | .055             | 12,500           | .14              | 19,500           | .225             | 26,500           | .32              | 34,000           | .49              |
| 6,000            | .06              | 13,000           | .145             | 20,000           | .230             | 27,000           | .33              | 35,000           | .51              |
| 6,500            | .07              | 13,500           | .15              | 20,500           | .24              | 27,500           | .34              | 36,000           | .53              |
| 7,000            | .075             | 14,000           | .155             | 21,000           | .245             | 28,000           | .35              | 37,000           | .56              |
| 7,500            | .075             | 14,500           | .16              | 21,500           | .25              | 28,500           | .36              |                  |                  |
| 8,000            | .08              | 15,000           | .165             | 22,000           | .255             | 29,000           | .37              |                  |                  |
| 8,500            | .09              | 15,500           | .17              | 22,500           | .265             | 29,500           | .38              |                  |                  |

Breaking weight of Beam I = 45,000 lbs.

TABLE B.

| Loads<br>in lbs. | Deflections of Beams. |       |       |       |       |       |       |
|------------------|-----------------------|-------|-------|-------|-------|-------|-------|
|                  | II                    | III   | IV    | V     | VI    | VII   | VIII  |
|                  | Ends.                 | Ends. | Ends. | Ends. | Ends. | Ends. | Ends. |
| 300              | .....                 | ..... | ..... | ..... | ..... | ..... | .02   |
| 500              | .....                 | .05   | ..... | .005  | .02   | .015  | .03   |
| 800              | .....                 | ..... | ..... | ..... | ..... | ..... | .05   |
| 1,000            | .....                 | .08   | .03   | .01   | .04   | .03   | .07   |
| 1,300            | .....                 | ..... | ..... | ..... | ..... | ..... | .09   |
| 1,500            | .....                 | .11   | .045  | .02   | .06   | .04   | .10   |
| 1,800            | .....                 | ..... | ..... | ..... | ..... | ..... | .12   |
| 2,000            | .035                  | .14   | .05   | .03   | .075  | .06   | .135  |
| 2,200            | .....                 | ..... | ..... | ..... | ..... | ..... | .15   |
| 2,400            | .....                 | ..... | ..... | ..... | ..... | ..... | .165  |
| 2,500            | .....                 | .155  | .055  | .05   | .10   | .075  | ..... |
| 2,600            | .....                 | ..... | ..... | ..... | ..... | ..... | .18   |
| 2,800            | .....                 | ..... | ..... | ..... | ..... | ..... | .195  |
| 3,000            | .....                 | .18   | .065  | .055  | .12   | .10   | .205  |
| 3,400            | .....                 | ..... | ..... | ..... | ..... | ..... | .235  |
| 3,500            | .....                 | .21   | .08   | .065  | .14   | .115  | ..... |
| 3,800            | .....                 | ..... | ..... | ..... | ..... | ..... | .26   |
| 4,000            | .05                   | .23   | .095  | .07   | .16   | .125  | .28   |
| 4,500            | .....                 | .25   | .105  | .08   | .18   | .14   | .315  |
| 5,000            | .....                 | ..... | .115  | .09   | .20   | .155  | .35   |
| 5,500            | .....                 | ..... | .13   | .105  | .22   | .175  | .39   |
| 6,000            | .065                  | ..... | .145  | .11   | .24   | .195  | ..... |
| 6,500            | .....                 | ..... | .155  | .125  | .26   | .21   | ..... |
| 7,000            | .....                 | ..... | .165  | .135  | .28   | .22   | ..... |
| 7,500            | .....                 | ..... | .18   | .145  | .305  | .235  | ..... |
| 8,000            | .075                  | ..... | .19   | .16   | .32   | .25   | ..... |
| 8,500            | .....                 | ..... | .20   | .17   | ..... | .27   | ..... |
| 9,000            | .....                 | ..... | .215  | .18   | ..... | ..... | ..... |
| 9,500            | .....                 | ..... | .23   | .195  | ..... | ..... | ..... |
| 10,000           | .085                  | ..... | .245  | .205  | ..... | ..... | ..... |
| 10,500           | .....                 | ..... | .26   | .22   | ..... | ..... | ..... |
| 11,000           | .....                 | ..... | .28   | .235  | ..... | ..... | ..... |
| 11,500           | .....                 | ..... | .30   | .25   | ..... | ..... | ..... |
| 12,000           | .10                   | ..... | .315  | .26   | ..... | ..... | ..... |
| 12,500           | .....                 | ..... | .33   | .27   | ..... | ..... | ..... |
| 13,000           | .105                  | ..... | .35   | .28   | ..... | ..... | ..... |
| 13,500           | .....                 | ..... | .365  | .29   | ..... | ..... | ..... |
| 14,000           | .110                  | ..... | .38   | .305  | ..... | ..... | ..... |
| 14,500           | .....                 | ..... | ..... | .315  | ..... | ..... | ..... |
| 15,000           | .115                  | ..... | ..... | .33   | ..... | ..... | ..... |
| 15,500           | .....                 | ..... | ..... | .345  | ..... | ..... | ..... |
| 16,000           | .12                   | ..... | ..... | ..... | ..... | ..... | ..... |
| 16,400           | .....                 | ..... | ..... | ..... | ..... | .75   | ..... |
| 17,000           | .13                   | ..... | ..... | ..... | ..... | ..... | ..... |
| 18,000           | .135                  | ..... | ..... | ..... | ..... | ..... | ..... |
| 20,000           | .14                   | ..... | ..... | ..... | ..... | ..... | ..... |
| 21,000           | .....                 | ..... | ..... | .72   | ..... | ..... | ..... |
| 22,000           | .15                   | ..... | ..... | ..... | ..... | ..... | ..... |
| 24,000           | .165                  | ..... | ..... | ..... | ..... | ..... | ..... |
| 26,000           | .175                  | ..... | ..... | ..... | ..... | ..... | ..... |
| 28,000           | .190                  | ..... | ..... | ..... | ..... | ..... | ..... |

Breaking Weight of Beam II = 36,575 lbs.

" " III = 12,950 "

" " IV = 16,720 "

" " V = 23,610 "

" " VI = 15,480 "

" " VII = 17,615 "

" " VIII = 11,700 "

TABLE C.

| Loads in<br>lbs. | Deflections of Beam IX. |         |       |         |         |         | Deflections of Beam X. |       |         |         |  |  |
|------------------|-------------------------|---------|-------|---------|---------|---------|------------------------|-------|---------|---------|--|--|
|                  | 34 ins.                 | 68 ins. | Ends. | 68 ins. | 34 ins. | 33 ins. | 66 ins.                | Ends. | 66 ins. | 33 ins. |  |  |
| 1000             | .01                     | .01     | .02   | .01     | .01     | .02     | .01                    | .02   | .01     | .02     |  |  |
| 1500             | .03                     | .02     | .04   | .02     | .03     | .05     | .02                    | .05   | .02     | .05     |  |  |
| 2000             | .03                     | .03     | .05   | .025    | .04     | .07     | .03                    | .08   | .04     | .07     |  |  |
| 2500             | .04                     | .03     | .05   | .03     | .05     | .10     | .05                    | .11   | .05     | .10     |  |  |
| 3000             | .10                     | .07     | .06   | .05     | .09     | .12     | .06                    | .14   | .06     | .12     |  |  |
| 3500             | .10                     | .08     | .12   | .05     | .10     | .15     | .07                    | .17   | .07     | .15     |  |  |
| 4000             | .10                     | .08     | .13   | .055    | .10     | .17     | .09                    | .20   | .08     | .17     |  |  |
| 4500             | .10                     | .08     | .14   | .065    | .11     | .20     | .10                    | .23   | .10     | .20     |  |  |
| 5000             | .15                     | .10     | .18   | .035    | .15     | .22     | .11                    | .26   | .115    | .22     |  |  |
| 5500             | .15                     | .11     | .19   | .09     | .16     | .25     | .12                    | .29   | .12     | .25     |  |  |
| 6000             | .15                     | .12     | .20   | .10     | .17     | .27     | .14                    | .32   | .14     | .27     |  |  |
| 6500             | .19                     | .13     | .24   | .11     | .20     | .30     | .15                    | .35   | .15     | .30     |  |  |
| 7000             | .20                     | .13     | .25   | .115    | .20     | .32     | .17                    | .38   | .16     | .32     |  |  |
| 7500             | .20                     | .13     | .25   | .11     | .21     | .35     | .18                    | .41   | .18     | .35     |  |  |
| 8000             | .20                     | .13     | .26   | .125    | .22     | .37     | .20                    | .41   | .20     | .37     |  |  |
| 8500             | .22                     | .14     | .27   | .135    | .24     | .40     | .21                    | .47   | .21     | .40     |  |  |
| 9000             | .22                     | .15     | .28   | .14     | .24     | .42     | .22                    | .50   | .22     | .42     |  |  |
| 9500             | .22                     | .15     | .28   | .145    | .25     | .45     | .23                    | .53   | .23     | .45     |  |  |
| 10000            | .26                     | .16     | .33   | .16     | .28     | .47     | .25                    | .56   | .24     | .47     |  |  |
| 10500            | .33                     | .20     | .40   | .19     | .34     | .49     | .26                    | .58   | .25     | .49     |  |  |
| 11000            | .34                     | .21     | .42   | .20     | .35     | .51     | .27                    | .61   | .27     | .51     |  |  |
| 11500            | .35                     | .22     | .44   | .205    | .36     | .54     | .29                    | .64   | .29     | .54     |  |  |
| 12000            | .39                     | .23     | .47   | .22     | .40     | .56     | .30                    | .68   | .30     | .56     |  |  |
| 12500            | .40                     | .24     | .49   | .22     | .40     | .59     | .32                    | .71   | .32     | .59     |  |  |
| 13000            | .40                     | .24     | .50   | .23     | .41     | .61     | .33                    | .74   | .33     | .61     |  |  |
| 13500            | .45                     | .27     | .54   | .25     | .45     | .64     | .34                    | .77   | .34     | .64     |  |  |
| 14000            | .45                     | .27     | .55   | .255    | .46     | .66     | .36                    | .80   | .36     | .66     |  |  |
| 14500            | .45                     | .27     | .56   | .26     | .46     | .69     | .37                    | .83   | .375    | .69     |  |  |
| 15000            | .50                     | .29     | .60   | .27     | .50     | .71     | .39                    | .86   | .39     | .71     |  |  |
| 15500            | .50                     | .30     | .61   | .28     | .51     | .74     | .40                    | .89   | .40     | .74     |  |  |
| 16000            | .50                     | .30     | .62   | .29     | .52     | .75     | .41                    | .92   | .41     | .76     |  |  |
| 16500            | .55                     | .31     | .66   | .31     | .55     | .79     | .43                    | .96   | .43     | .79     |  |  |
| 17000            | .55                     | .32     | .67   | .31     | .56     | .81     | .44                    | .99   | .45     | .82     |  |  |
| 17500            | .56                     | .33     | .68   | .32     | .57     | .85     | .46                    | 1.02  | .46     | .85     |  |  |
| 18000            | .56                     | .33     | .69   | .325    | .58     | .....   | .....                  | ..... | .....   | .....   |  |  |
| 18500            | .60                     | .36     | .75   | .35     | .62     | .....   | .....                  | ..... | .....   | .....   |  |  |
| 19000            | .63                     | .36     | .77   | .35     | .64     | .....   | .....                  | ..... | .....   | .....   |  |  |
| 19500            | .64                     | .37     | .78   | .36     | .65     | .....   | .....                  | ..... | .....   | .....   |  |  |
| 20000            | .65                     | .37     | .79   | .365    | .66     | .....   | .....                  | ..... | .....   | .....   |  |  |
| 40000            | .....                   | .....   | 1.75  | .....   | .....   | .....   | .....                  | ..... | .....   | .....   |  |  |
| 47000            | .....                   | .....   | 2.20  | .....   | .....   | .....   | .....                  | ..... | .....   | .....   |  |  |

Breaking Weight of Beam IX = 51,600 lbs.

" " " X = 18,000 "

TABLE D.

| Loads in<br>lbs. | Deflections of Beam XI. |         |       |         |         |         | Deflections of Beam XII. |       |         |         |         |         |
|------------------|-------------------------|---------|-------|---------|---------|---------|--------------------------|-------|---------|---------|---------|---------|
|                  | 34 ins.                 | 68 ins. | Ends. | 68 ins. | 34 ins. | 34 ins. | 68 ins.                  | Ends. | 68 ins. | 34 ins. | 34 ins. | 34 ins. |
| 1000             | .....                   | .....   | ..... | .....   | .....   | .01     | .005                     | .01   | .01     | .01     | .....   | .....   |
| 1500             | .02                     | .01     | .035  | .015    | .025    | .03     | .02                      | .035  | .02     | .035    | .....   | .....   |
| 2000             | .05                     | .02     | .05   | .025    | .04     | .05     | .025                     | .055  | .03     | .05     | .....   | .....   |
| 2500             | .06                     | .03     | .075  | .035    | .06     | .065    | .04                      | .075  | .05     | .07     | .....   | .....   |
| 3000             | .075                    | .04     | .10   | .045    | .08     | .09     | .045                     | .10   | .05     | .09     | .....   | .....   |
| 3500             | .10                     | .05     | .115  | .055    | .095    | .105    | .06                      | .12   | .06     | .105    | .....   | .....   |
| 4000             | .11                     | .06     | .135  | .06     | .11     | .12     | .07                      | .145  | .07     | .12     | .....   | .....   |
| 4500             | .13                     | .07     | .16   | .07     | .135    | .15     | .075                     | .165  | .08     | .145    | .....   | .....   |
| 5000             | .15                     | .075    | .175  | .075    | .14     | .155    | .09                      | .185  | .09     | .155    | .....   | .....   |
| 5500             | .16                     | .085    | .20   | .09     | .16     | .17     | .10                      | .205  | .10     | .17     | .....   | .....   |
| 6000             | .185                    | .10     | .22   | .10     | .18     | .19     | .11                      | .23   | .11     | .19     | .....   | .....   |
| 6500             | .20                     | .105    | .24   | .11     | .195    | .21     | .12                      | .25   | .12     | .21     | .....   | .....   |
| 7000             | .215                    | .115    | .26   | .11     | .215    | .23     | .13                      | .27   | .13     | .235    | .....   | .....   |
| 7500             | .24                     | .125    | .28   | .13     | .235    | .25     | .14                      | .295  | .14     | .25     | .....   | .....   |
| 8000             | .25                     | .135    | .30   | .14     | .245    | .27     | .15                      | .315  | .15     | .27     | .....   | .....   |
| 8500             | .26                     | .145    | .32   | .15     | .265    | .29     | .15                      | .34   | .16     | .29     | .....   | .....   |
| 9000             | .27                     | .15     | .33   | .155    | .27     | .305    | .17                      | .36   | .17     | .305    | .....   | .....   |
| 9500             | .30                     | .16     | .35   | .165    | .29     | .32     | .18                      | .305  | .18     | .32     | .....   | .....   |
| 10000            | .315                    | .17     | .38   | .175    | .305    | .35     | .19                      | .405  | .19     | .35     | .....   | .....   |
| 10500            | .34                     | .185    | .40   | .185    | .335    | .36     | .20                      | .425  | .20     | .36     | .....   | .....   |
| 11000            | .36                     | .195    | .435  | .20     | .36     | .375    | .21                      | .45   | .21     | .38     | .....   | .....   |
| 11500            | .36                     | .20     | .435  | .20     | .36     | .39     | .22                      | .47   | .22     | .40     | .....   | .....   |
| 12000            | .395                    | .215    | .475  | .22     | .395    | .41     | .23                      | .495  | .23     | .41     | .....   | .....   |
| 12500            | .40                     | .22     | .50   | .23     | .405    | .44     | .24                      | .51   | .24     | .44     | .....   | .....   |
| 13000            | .42                     | .23     | .505  | .24     | .42     | .45     | .25                      | .535  | .25     | .45     | .....   | .....   |
| 13500            | .45                     | .25     | .54   | .255    | .445    | .47     | .26                      | .555  | .26     | .47     | .....   | .....   |
| 14000            | .46                     | .255    | .56   | .265    | .46     | .49     | .27                      | .58   | .27     | .49     | .....   | .....   |
| 14500            | .48                     | .265    | .57   | .275    | .475    | .50     | .28                      | .60   | .28     | .505    | .....   | .....   |
| 15000            | .50                     | .275    | .60   | .28     | .50     | .52     | .29                      | .62   | .30     | .52     | .....   | .....   |
| 15500            | .515                    | .285    | .62   | .29     | .515    | .55     | .30                      | .645  | .305    | .55     | .....   | .....   |
| 16000            | .535                    | .295    | .645  | .30     | .53     | .555    | .305                     | .665  | .31     | .56     | .....   | .....   |
| 16500            | .54                     | .30     | .65   | .30     | .535    | .575    | .32                      | .69   | .32     | .57     | .....   | .....   |
| 17000            | .58                     | .32     | .695  | .32     | .575    | .60     | .325                     | .71   | .33     | .60     | .....   | .....   |
| 17500            | .585                    | .32     | .70   | .325    | .575    | .61     | .33                      | .73   | .345    | .615    | .....   | .....   |
| 18000            | .61                     | .34     | .735  | .345    | .61     | .63     | .345                     | .755  | .35     | .635    | .....   | .....   |
| 18500            | .61                     | .34     | .745  | .35     | .615    | .65     | .35                      | .77   | .36     | .65     | .....   | .....   |
| 19000            | .65                     | .36     | .78   | .365    | .655    | .665    | .36                      | .80   | .375    | .665    | .....   | .....   |
| 19500            | .65                     | .36     | .785  | .375    | .655    | .685    | .37                      | .82   | .385    | .69     | .....   | .....   |
| 20000            | .655                    | .365    | .80   | .375    | .66     | .705    | .38                      | .85   | .40     | .705    | .....   | .....   |
| 20500            | .....                   | .....   | ..... | .....   | .....   | .73     | .395                     | .87   | .41     | .725    | .....   | .....   |
| 21000            | .....                   | .....   | ..... | .....   | .....   | .75     | .40                      | .89   | .415    | .75     | .....   | .....   |
| 21500            | .....                   | .....   | ..... | .....   | .....   | .75     | .405                     | .90   | .415    | .75     | .....   | .....   |
| 22000            | .....                   | .....   | ..... | .....   | .....   | .78     | .42                      | .935  | .435    | .78     | .....   | .....   |
| 22500            | .....                   | .....   | ..... | .....   | .....   | .81     | .435                     | .96   | .45     | .805    | .....   | .....   |
| 23000            | .....                   | .....   | ..... | .....   | .....   | .82     | .445                     | .98   | .455    | .82     | .....   | .....   |
| 24000            | .....                   | .....   | .94   | .....   | .....   | .....   | .....                    | ..... | .....   | .....   | .....   | .....   |
| 26500            | .....                   | .....   | 1.14  | .....   | .....   | .....   | .....                    | 1.12  | .....   | .....   | .....   | .....   |
| 28000            | .....                   | .....   | 1.14  | .....   | .....   | .....   | .....                    | 1.17  | .....   | .....   | .....   | .....   |
| 29000            | .....                   | .....   | ..... | .....   | .....   | .....   | .....                    | 1.22  | .....   | .....   | .....   | .....   |
| 32000            | .....                   | .....   | ..... | .....   | .....   | .....   | .....                    | 1.40  | .....   | .....   | .....   | .....   |
| 33000            | .....                   | .....   | 1.35  | .....   | .....   | .....   | .....                    | 1.42  | .....   | .....   | .....   | .....   |
| 35800            | .....                   | .....   | 1.45  | .....   | .....   | .....   | .....                    | 1.67  | .....   | .....   | .....   | .....   |
| 37000            | .....                   | .....   | ..... | .....   | .....   | .....   | .....                    | 1.97  | .....   | .....   | .....   | .....   |
| 39000            | .....                   | .....   | ..... | .....   | .....   | .....   | .....                    | 2.00  | .....   | .....   | .....   | .....   |
| 42000            | .....                   | .....   | ..... | .....   | .....   | .....   | .....                    | 2.28  | .....   | .....   | .....   | .....   |
| 45000            | .....                   | .....   | ..... | .....   | .....   | .....   | .....                    | 2.73  | .....   | .....   | .....   | .....   |
| 48000            | .....                   | .....   | ..... | .....   | .....   | .....   | .....                    | 2.9   | .....   | .....   | .....   | .....   |

Breaking Weight of Beam XI = 35,800 lbs.  
 " " " XII = 49,000 "

TABLE E.

| Load in lbs. | Deflections of Beam XIII. |            |      |            |            |       | Deflection<br>of Beam<br>XIV. | Deflections of Beam XV. |            |       |            |            |       | Deflection<br>of Beam<br>XVI. |
|--------------|---------------------------|------------|------|------------|------------|-------|-------------------------------|-------------------------|------------|-------|------------|------------|-------|-------------------------------|
|              | 31<br>ins.                | 68<br>ins. | Ends | 68<br>ins. | 34<br>ins. | Ends. |                               | 33<br>ins.              | 66<br>ins. | Ends. | 66<br>ins. | 33<br>ins. | Ends. |                               |
| 760          | ...                       | ...        | ...  | ...        | ...        | .03   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 1000         | .25                       | .02        | .04  | .02        | .025       | .05   | .01                           | .01                     | .02        | .01   | .02        | .02        | .025  | ...                           |
| 1140         | ...                       | ...        | ...  | ...        | ...        | ...   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .035                          |
| 1500         | .05                       | .035       | .07  | .03        | .05        | .085  | .04                           | .02                     | .05        | .025  | .04        | .05        | ...   | ...                           |
| 1900         | ...                       | ...        | ...  | ...        | ...        | ...   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .075                          |
| 2000         | .08                       | .05        | .105 | .05        | .08        | .115  | .055                          | .035                    | .08        | .045  | .06        | ...        | ...   | ...                           |
| 2300         | ...                       | ...        | ...  | ...        | ...        | ...   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .09                           |
| 2500         | .10                       | .065       | .14  | .065       | .11        | .15   | .08                           | .045                    | .095       | .05   | .075       | ...        | ...   | ...                           |
| 2600         | ...                       | ...        | ...  | ...        | ...        | ...   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .10                           |
| 2800         | ...                       | ...        | ...  | ...        | ...        | .17   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 3000         | .14                       | .08        | .17  | .08        | .14        | .19   | .10                           | .05                     | .115       | .06   | .10        | ...        | ...   | .125                          |
| 3200         | ...                       | ...        | ...  | ...        | ...        | .20   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 3400         | ...                       | ...        | ...  | ...        | ...        | .22   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .145                          |
| 3500         | .16                       | .10        | .21  | .10        | .16        | ...   | .11                           | .065                    | .14        | .07   | .12        | ...        | ...   | ...                           |
| 3600         | ...                       | ...        | ...  | ...        | ...        | .225  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 3800         | ...                       | ...        | ...  | ...        | ...        | .25   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .16                           |
| 4000         | .20                       | .11        | .215 | .11        | .20        | .255  | .13                           | .08                     | .16        | .085  | .14        | ...        | ...   | .175                          |
| 4440         | ...                       | ...        | ...  | ...        | ...        | .275  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .20                           |
| 4500         | .22                       | .13        | .275 | .125       | .22        | ...   | .155                          | .095                    | .185       | .095  | .16        | ...        | ...   | ...                           |
| 4800         | ...                       | ...        | ...  | ...        | ...        | .315  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .215                          |
| 5000         | .25                       | .145       | .31  | .14        | .25        | .32   | .165                          | .105                    | .215       | .105  | .17        | ...        | ...   | .225                          |
| 5200         | ...                       | ...        | ...  | ...        | ...        | .345  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .23                           |
| 5400         | ...                       | ...        | ...  | ...        | ...        | .355  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 5500         | .275                      | .15        | .31  | .155       | .275       | ...   | .19                           | .11                     | .24        | .115  | .20        | ...        | ...   | ...                           |
| 5600         | ...                       | ...        | ...  | ...        | ...        | .36   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .25                           |
| 5800         | ...                       | ...        | ...  | ...        | ...        | .39   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 6000         | .30                       | .165       | .36  | .17        | .30        | .40   | .21                           | .125                    | .26        | .125  | .215       | ...        | ...   | .27                           |
| 6400         | ...                       | ...        | ...  | ...        | ...        | ...   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .29                           |
| 6500         | .33                       | .18        | .40  | .185       | .33        | ...   | .23                           | .13                     | .285       | .14   | .235       | ...        | ...   | ...                           |
| 6600         | ...                       | ...        | ...  | ...        | ...        | .435  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 6800         | ...                       | ...        | ...  | ...        | ...        | .465  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .31                           |
| 7000         | .36                       | .20        | .44  | .20        | .36        | .485  | .255                          | .145                    | .31        | .15   | .255       | ...        | ...   | .325                          |
| 7200         | ...                       | ...        | ...  | ...        | ...        | .50   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 7400         | ...                       | ...        | ...  | ...        | ...        | .505  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .34                           |
| 7500         | .38                       | .215       | .47  | .22        | .39        | ...   | .27                           | .155                    | .335       | .16   | .275       | ...        | ...   | ...                           |
| 7800         | ...                       | ...        | ...  | ...        | ...        | .54   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .36                           |
| 8000         | .41                       | .225       | .50  | .23        | .41        | .56   | .295                          | .165                    | .35        | .175  | .30        | ...        | ...   | .375                          |
| 8300         | ...                       | ...        | ...  | ...        | ...        | .585  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 8400         | ...                       | ...        | ...  | ...        | ...        | ...   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .40                           |
| 8500         | .45                       | .245       | .54  | .245       | .45        | ...   | .31                           | .18                     | .38        | .18   | .315       | ...        | ...   | ...                           |
| 8600         | ...                       | ...        | ...  | ...        | ...        | .605  | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 8800         | ...                       | ...        | ...  | ...        | ...        | ...   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .42                           |
| 9000         | .46                       | .255       | .57  | .26        | .47        | .64   | .34                           | .19                     | .40        | .19   | .34        | ...        | ...   | .425                          |
| 9200         | ...                       | ...        | ...  | ...        | ...        | .66   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | ...                           |
| 9400         | ...                       | ...        | ...  | ...        | ...        | ...   | ...                           | ...                     | ...        | ...   | ...        | ...        | ...   | .45                           |

TABLE E.—(Continued.)

| Loads<br>in<br>lbs. | Deflections of Beam XIII. |            |       |            |            |      | Deflections of<br>Beam XIV. | Deflections of Beam XV. |            |      |            |            |      | Deflections of<br>Beam XVI. |
|---------------------|---------------------------|------------|-------|------------|------------|------|-----------------------------|-------------------------|------------|------|------------|------------|------|-----------------------------|
|                     | 34<br>ins.                | 68<br>ins. | Ends  | 68<br>ins. | 34<br>ins. | Ends |                             | 33<br>ins.              | 66<br>ins. | Ends | 66<br>ins. | 33<br>ins. | Ends |                             |
|                     |                           |            |       |            |            |      |                             |                         |            |      |            |            |      |                             |
| 9500                | .50                       | .275       | .605  | .28        | .50        | .... | .35                         | .20                     | .425       | .205 | .355       | ....       | .... |                             |
| 9600                | ....                      | ....       | ....  | ....       | ....       | .69  | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 9800                | ....                      | ....       | ....  | ....       | ....       | .715 | ....                        | ....                    | ....       | .... | ....       | ....       | .475 |                             |
| 10000               | .52                       | .29        | .64   | .295       | .53        | .73  | .37                         | .21                     | .44        | .21  | .375       | .485       | .... |                             |
| 10200               | ....                      | ....       | ....  | ....       | ....       | .76  | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 10400               | ....                      | ....       | ....  | ....       | ....       | .765 | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 10500               | .55                       | .305       | .67   | .31        | .55        | .... | .40                         | .22                     | .475       | .22  | .40        | ....       | .... |                             |
| 10600               | ....                      | ....       | ....  | ....       | ....       | .80  | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 10800               | ....                      | ....       | ....  | ....       | ....       | .805 | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 11000               | .585                      | .32        | .705  | .325       | .585       | .... | .415                        | .23                     | .50        | .24  | .415       | .54        | .... |                             |
| 11300               | ....                      | ....       | ....  | ....       | ....       | .845 | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 11500               | .61                       | .34        | .745  | .345       | .61        | .... | .44                         | .24                     | .525       | .25  | .445       | .565       | .... |                             |
| 11700               | ....                      | ....       | ....  | ....       | ....       | .88  | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 12000               | .64                       | .35        | .78   | .36        | .64        | .91  | .45                         | .255                    | .55        | .26  | .45        | .59        | .... |                             |
| 12200               | ....                      | ....       | ....  | ....       | ....       | .935 | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 12400               | ....                      | ....       | ....  | ....       | ....       | .95  | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 12500               | .66                       | .365       | .81   | .375       | .67        | .... | .47                         | .265                    | .57        | .27  | .465       | .61        | .... |                             |
| 12600               | ....                      | ....       | ....  | ....       | ....       | .955 | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 12800               | ....                      | ....       | ....  | ....       | ....       | 1.00 | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 13000               | .70                       | .385       | .845  | .395       | .70        | 1.00 | .495                        | .275                    | .60        | .28  | .50        | .65        | .... |                             |
| 13200               | ....                      | ....       | ....  | ....       | ....       | 1.02 | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 13500               | .725                      | .40        | .885  | .41        | .735       | .... | .51                         | .285                    | .62        | .29  | .51        | .68        | .... |                             |
| 14000               | .75                       | .415       | .915  | .42        | .76        | .... | .54                         | .295                    | .64        | .30  | .54        | .71        | .... |                             |
| 14500               | .795                      | .435       | .96   | .445       | .795       | .... | .55                         | .305                    | .66        | .31  | .55        | .73        | .... |                             |
| 15000               | .81                       | .45        | .99   | .46        | .82        | .... | .57                         | .32                     | .69        | .32  | .575       | .75        | .... |                             |
| 15500               | .85                       | .47        | 1.025 | .475       | .85        | .... | .59                         | .33                     | .715       | .335 | .60        | .78        | .... |                             |
| 16000               | .875                      | .485       | 1.065 | .49        | .875       | .... | .61                         | .34                     | .74        | .34  | .615       | .81        | .... |                             |
| 16500               | .905                      | .505       | 1.10  | .515       | .915       | .... | .64                         | .35                     | .765       | .35  | .64        | .83        | .... |                             |
| 17000               | .94                       | .52        | 1.135 | .525       | .94        | .... | .65                         | .36                     | .79        | .36  | .655       | .87        | .... |                             |
| 17500               | .97                       | .54        | 1.18  | .545       | .975       | .... | .67                         | .375                    | .81        | .375 | .675       | .90        | .... |                             |
| 18000               | 1.00                      | .55        | 1.22  | .56        | 1.01       | .... | .69                         | .385                    | .835       | .39  | .70        | .93        | .... |                             |
| 18500               | 1.04                      | .575       | 1.265 | .58        | 1.045      | .... | .71                         | .395                    | .86        | .40  | .71        | .95        | .... |                             |
| 19000               | 1.06                      | .59        | 1.31  | .60        | 1.07       | .... | .74                         | .405                    | .875       | .41  | .735       | .98        | .... |                             |
| 19500               | 1.1                       | .615       | 1.35  | .62        | 1.1        | .... | .75                         | .415                    | .91        | .42  | .75        | 1.00       | .... |                             |
| 20000               | 1.14                      | .63        | 1.39  | .635       | 1.14       | .... | .77                         | .425                    | .94        | .43  | .775       | 1.04       | .... |                             |
| 20500               | 1.165                     | .65        | 1.43  | .655       | 1.175      | .... | ....                        | ....                    | ....       | .... | ....       | ....       | 1.07 |                             |
| 21000               | 1.21                      | .67        | 1.485 | .68        | 1.22       | .... | ....                        | ....                    | 1.20       | .... | ....       | ....       | 1.10 |                             |
| 21500               | 1.24                      | .685       | 1.515 | .69        | 1.25       | .... | ....                        | ....                    | ....       | .... | ....       | ....       | 1.13 |                             |
| 22000               | 1.28                      | .71        | 1.57  | .715       | 1.29       | .... | ....                        | ....                    | ....       | .... | ....       | ....       | 1.15 |                             |
| 22500               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | ....                    | ....       | .... | ....       | ....       | 1.17 |                             |
| 23000               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | ....                    | ....       | .... | ....       | ....       | 1.20 |                             |
| 24000               | ....                      | ....       | 1.70  | ....       | ....       | .... | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 25000               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | 1.30                    | ....       | .... | ....       | ....       | .... |                             |
| 26000               | ....                      | ....       | 1.88  | ....       | ....       | .... | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 26300               | ....                      | ....       | 2.05  | ....       | ....       | .... | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |
| 27000               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | 1.45                    | ....       | .... | ....       | ....       | .... |                             |
| 29000               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | 1.55                    | ....       | .... | ....       | ....       | .... |                             |
| 29300               | ....                      | ....       | 2.6   | ....       | ....       | .... | ....                        | 1.70                    | ....       | .... | ....       | ....       | .... |                             |
| 30000               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | 1.90                    | ....       | .... | ....       | ....       | .... |                             |
| 32000               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | 2.25                    | ....       | .... | ....       | ....       | .... |                             |
| 35000               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | 2.33                    | ....       | .... | ....       | ....       | .... |                             |
| 37000               | ....                      | ....       | ....  | ....       | ....       | .... | ....                        | ....                    | ....       | .... | ....       | ....       | .... |                             |

Breaking weight of Beam XIII = 29,300 lbs.

" " " XIV = 17,600 "

" " " XV = 37,000 "

" " " XVI = 25,580 to 32,000 lbs.

TABLE F.

Deflections of Beams XVII, XVIII and XIX.

| Load<br>in<br>lbs. | XVII.             |      |                   |      | XVIII.                                    |      |                          |      | XIX.                                   |      |                          |     |
|--------------------|-------------------|------|-------------------|------|---|------|--------------------------|------|--|------|--------------------------|-----|
|                    | 1st Load-<br>ing. |      | 2nd Load-<br>ing. |      | Beam grad-<br>ually re-<br>lieved of load |      | 1st Loading.             |      | Beam gradually<br>relieved of<br>load. |      | 2nd<br>load-<br>ing.     |     |
|                    | Ends.             | Ends | Ends              | Ends | Ends                                      | Ends | 34 $\frac{1}{2}$<br>ins. | End  | 34 $\frac{1}{2}$<br>ins.               | End  | 34 $\frac{1}{2}$<br>ins. | End |
| 1000               | .005              | .005 | .015              | .    | .005                                      | .010 | .010                     | .010 | .015                                   | .020 | .                        | .   |
| 2000               | .010              | .015 | .015              | .    | .020                                      | .045 | .030                     | .    | .                                      | .    | .                        | .   |
| 3000               | .020              | .030 | .020              | .    | .050                                      | .060 | .055                     | .    | .                                      | .    | .                        | .   |
| 4000               | .030              | .030 | .030              | .    | .060                                      | .090 | .070                     | .055 | .095                                   | .060 | .                        | .   |
| 5000               | .07               | .040 | .040              | .045 | .   | .070 | .105                     | .085 | .                                      | .    | .                        | .   |
| 6000               | .                 | .050 | .050              | .050 | .   | .090 | .130                     | .100 | .                                      | .    | .                        | .   |
| 7000               | .                 | .060 | .060              | .060 | .   | .110 | .150                     | .105 | .                                      | .    | .                        | .   |
| 7500               | .                 | .065 | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 8000               | .                 | .075 | .070              | .070 | .   | .115 | .170                     | .125 | .120                                   | .190 | .120                     | .   |
| 8500               | .                 | .    | .                 | .    | .   | .120 | .185                     | .135 | .                                      | .    | .                        | .   |
| 9000               | .                 | .080 | .085              | .075 | .   | .130 | .200                     | .140 | .                                      | .    | .                        | .   |
| 9500               | .                 | .    | .                 | .    | .   | .140 | .215                     | .145 | .                                      | .    | .                        | .   |
| 10000              | .15               | .095 | .095              | .085 | .   | .150 | .225                     | .150 | .                                      | .    | .                        | .   |
| 10500              | .                 | .100 | .                 | .    | .   | .155 | .235                     | .160 | .                                      | .    | .                        | .   |
| 11000              | .                 | .100 | .103              | .095 | .   | .160 | .243                     | .165 | .                                      | .    | .                        | .   |
| 11500              | .                 | .    | .                 | .    | .   | .165 | .250                     | .170 | .                                      | .    | .                        | .   |
| 12000              | .                 | .110 | .110              | .100 | .   | .170 | .265                     | .180 | .170                                   | .255 | .170                     | .   |
| 12500              | .18               | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 13000              | .                 | .    | .130              | .110 | .   | .180 | .290                     | .190 | .                                      | .    | .                        | .   |
| 14000              | .                 | .    | .130              | .125 | .   | .200 | .310                     | .205 | .                                      | .    | .                        | .   |
| 15000              | .22               | .    | .140              | .130 | .   | .210 | .330                     | .220 | .                                      | .    | .                        | .   |
| 16000              | .                 | .    | .150              | .150 | .   | .225 | .345                     | .230 | .                                      | .    | .                        | .   |
| 17000              | .                 | .    | .165              | .165 | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 17500              | .26               | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 18000              | .                 | .    | .175              | .170 | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 19000              | .                 | .    | .185              | .185 | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 20000              | .30               | .    | .                 | .    | .200                                      | .    | .                        | .    | .                                      | .420 | .                        | .   |
| 22000              | .                 | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .465 | .                        | .   |
| 22500              | .34               | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .510 | .                        | .   |
| 24000              | .                 | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .550                     | .   |
| 25000              | .385              | .    | .                 | .    | .220                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 26000              | .405              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .600                     | .   |
| 27000              | .425              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 28000              | .445              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .640                     | .   |
| 29000              | .465              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 30000              | .485              | .    | .                 | .    | .240                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 31000              | .510              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 32000              | .535              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 33000              | .560              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 34000              | .585              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 35000              | .61               | .    | .                 | .    | .310                                      | .    | .                        | .    | .                                      | .730 | .                        | .   |
| 36000              | .64               | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .780                     | .   |
| 37000              | .68               | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 38000              | .715              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 39000              | .75               | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .830                     | .   |
| 40000              | .795              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 41000              | .850              | .    | .                 | .    | .340                                      | .    | .                        | .    | .                                      | .870 | .                        | .   |
| 42000              | .980              | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 42500              | 1.005             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .930                     | .   |
| 43000              | 1.030             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 43500              | 1.055             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 44000              | 1.085             | .    | .                 | .    | .350                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 44500              | 1.125             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .980                     | .   |
| 45000              | 1.150             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 45500              | 1.240             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 46000              | 1.285             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | 1.030                    | .   |
| 46500              | 1.315             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 47000              | 1.365             | .    | .                 | .    | .400                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 47500              | 1.455             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 48000              | 1.600             | .    | .                 | .    | .440                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 48100              | 1.640             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 48200              | 1.675             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 48300              | 1.720             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 48400              | 1.830             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 48500              | 1.910             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 48600              | 2.020             | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 50000              | .                 | .    | .                 | .    | .490                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 52000              | .                 | .    | .                 | .    | .500                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 54000              | .                 | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 56000              | .                 | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 57000              | .                 | .    | .                 | .    | .540                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 58000              | .                 | .    | .                 | .    | .   | .    | .                        | .    | .                                      | .    | .                        | .   |
| 61000              | .                 | .    | .                 | .    | .630                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 64000              | .                 | .    | .                 | .    | .700                                      | .    | .                        | .    | .                                      | .    | .                        | .   |
| 67000              | .                 | .    | .                 | .    | .750                                      | .    | .                        | .    | .                                      | .    | .                        | .   |

Breaking weight of Beam XVII = 48,600 lbs.

" " " XVIII = 69,400 "

" " " XIX = 59,540 "

TABLE G.

Deflections of Beams XX and XXI.

| Load<br>in<br>lbs. | XX.                      |      |                          |       |                          |      |                          |       | XXI.                     |      |                          |       |                          |       |                          |  |
|--------------------|--------------------------|------|--------------------------|-------|--------------------------|------|--------------------------|-------|--------------------------|------|--------------------------|-------|--------------------------|-------|--------------------------|--|
|                    | 1st Loading.             |      |                          |       | 2nd Loading.             |      |                          |       | 1st Loading.             |      |                          |       | 2nd Loading.             |       |                          |  |
|                    | 34 $\frac{1}{2}$<br>ins. | End  | 34 $\frac{1}{2}$<br>ins. | Ends. | 34 $\frac{1}{2}$<br>ins. | Ends | 34 $\frac{1}{2}$<br>ins. | Ends. | 34 $\frac{1}{2}$<br>ins. | E'ds | 34 $\frac{1}{2}$<br>ins. | Ends. | 34 $\frac{1}{2}$<br>ins. | Ends  | 34 $\frac{1}{2}$<br>ins. |  |
| 250                | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .009                     | .02  | .010                     | .020  | .015                     | .020  | .015                     |  |
| 500                | .0                       | .0   | .0                       | .001  | .003                     | .005 | .005                     | .025  | .035                     | .025 | ...                      | ...   | ...                      | ...   | ...                      |  |
| 750                | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .0375                    | .065 | .045                     | ...   | ...                      | ...   | ...                      |  |
| 1000               | .015                     | .016 | .015                     | ...   | ...                      | ...  | ...                      | ...   | .055                     | .085 | .060                     | .095  | .065                     | .095  | .065                     |  |
| 1250               | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .075                     | .110 | .075                     | ...   | ...                      | ...   | ...                      |  |
| 1500               | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .095                     | .135 | .090                     | ...   | ...                      | ...   | ...                      |  |
| 1750               | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .110                     | .115 | .110                     | ...   | ...                      | ...   | ...                      |  |
| 2000               | .035                     | .040 | .040                     | .045  | .035                     | .045 | .040                     | .120  | .185                     | .125 | .195                     | .120  | .185                     | .125  | ...                      |  |
| 2250               | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .140                     | .205 | .140                     | ...   | ...                      | ...   | ...                      |  |
| 2500               | .048                     | .050 | .050                     | ...   | ...                      | ...  | ...                      | ...   | .155                     | .230 | .155                     | ...   | ...                      | ...   | ...                      |  |
| 3000               | .050                     | .080 | .055                     | ...   | ...                      | ...  | ...                      | ...   | .185                     | .275 | .185                     | .280  | .190                     | .285  | .185                     |  |
| 3500               | .055                     | .090 | .065                     | ...   | ...                      | ...  | ...                      | ...   | .220                     | .325 | .215                     | ...   | ...                      | ...   | ...                      |  |
| 4000               | .070                     | .105 | .080                     | .105  | .070                     | .105 | .075                     | .255  | .370                     | .250 | .375                     | .255  | .370                     | .250  | ...                      |  |
| 4250               | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .270                     | .405 | .270                     | ...   | ...                      | ...   | ...                      |  |
| 4500               | .084                     | .115 | .090                     | ...   | ...                      | ...  | ...                      | ...   | .285                     | .430 | .285                     | ...   | ...                      | ...   | ...                      |  |
| 4750               | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .302                     | .455 | .300                     | ...   | ...                      | ...   | ...                      |  |
| 5000               | .095                     | .125 | .100                     | ...   | ...                      | ...  | ...                      | ...   | .317                     | .470 | .315                     | .470  | .315                     | .470  | .315                     |  |
| 5250               | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .335                     | .495 | .330                     | ...   | ...                      | ...   | ...                      |  |
| 5500               | .100                     | .140 | .105                     | ...   | ...                      | ...  | ...                      | ...   | .350                     | .520 | .345                     | ...   | ...                      | ...   | ...                      |  |
| 5750               | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | .365                     | .545 | .360                     | ...   | ...                      | ...   | ...                      |  |
| 6000               | .110                     | .155 | .115                     | .160  | .105                     | .160 | .110                     | .380  | .565                     | .375 | .575                     | .380  | .575                     | .380  | ...                      |  |
| 6500               | .120                     | .170 | .120                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 7000               | .130                     | .185 | .135                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .415  | .665                     | .440  | ...                      |  |
| 7500               | .135                     | .200 | .140                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 8000               | .146                     | .210 | .150                     | .215  | .145                     | .215 | .150                     | ...   | ...                      | ...  | ...                      | .515  | .765                     | .515  | ...                      |  |
| 8500               | .152                     | .225 | .160                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 9000               | .163                     | .240 | .170                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .580  | .870                     | .575  | ...                      |  |
| 9500               | .175                     | .255 | .180                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 10000              | .180                     | .270 | .190                     | .270  | .180                     | .270 | .185                     | ...   | ...                      | ...  | ...                      | .645  | .970                     | .640  | ...                      |  |
| 10500              | .194                     | .285 | .200                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 11000              | .206                     | .300 | .205                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .715  | 1.075                    | .700  | ...                      |  |
| 11500              | .210                     | .315 | .220                     | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 12000              | .220                     | .325 | .230                     | .325  | .215                     | .325 | .235                     | ...   | ...                      | ...  | ...                      | .785  | 1.170                    | .765  | ...                      |  |
| 13000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | 1.310 | ...                      |  |
| 14000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .255  | .380                     | .260 | ...                      | ...   | ...                      | ...   | ...                      |  |
| 15000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .285  | .430                     | .290 | ...                      | ...   | ...                      | 1.515 | ...                      |  |
| 16000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .285  | .430                     | .290 | ...                      | ...   | ...                      | 1.670 | ...                      |  |
| 17000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | 1.850 | ...                      |  |
| 17400              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | 2.000 | ...                      |  |
| 17500              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | ...   | ...                      | 2.40  | ...                      |  |
| 18000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .320  | .485                     | .325 | ...                      | ...   | ...                      | ...   | ...                      |  |
| 20000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .360  | .545                     | .370 | ...                      | ...   | ...                      | ...   | ...                      |  |
| 22000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .400  | .505                     | .410 | ...                      | ...   | ...                      | ...   | ...                      |  |
| 24000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .440  | .665                     | .450 | ...                      | ...   | ...                      | ...   | ...                      |  |
| 26000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .725  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 28000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .791  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 30000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .850  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 32000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .920  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 34000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | .990  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 36000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | 1.06  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 38000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | 1.50  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 40000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | 2.40  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 42000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | 3.60  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 44000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | 5.05  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 46000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | 6.60  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |
| 48000              | ...                      | ...  | ...                      | ...   | ...                      | ...  | ...                      | 7.03  | ...                      | ...  | ...                      | ...   | ...                      | ...   | ...                      |  |

Breaking weight of Beam XX = 49,600 lbs.  
" " " " XXI = 17,960 "

Tables H and I show deflections in inches of Old Douglas Fir, etc.

TABLE H.

Deflections of Beams XXII and XXIII.

| Loads<br>in lbs. | XXII.      |            |       |            |            | XXIII.     |            |       |            |            |
|------------------|------------|------------|-------|------------|------------|------------|------------|-------|------------|------------|
|                  | 27<br>ins. | 54<br>ins. | Ends  | 54<br>ins. | 27<br>ins. | 31<br>ins. | 62<br>ins. | Ends. | 62<br>ins. | 31<br>ins. |
| 1,000            | .....      | .....      | ..... | .....      | .....      | .015       | .01        | .015  | .00        | .01        |
| 1,500            | .02        | .01        | .02   | .01        | .01        | .025       | .02        | .025  | .01        | .02        |
| 2,000            | .025       | .02        | .03   | .01        | .02        | .04        | .03        | .045  | .02        | .035       |
| 2,500            | .04        | .025       | .04   | .02        | .03        | .05        | .045       | .05   | .025       | .045       |
| 3,000            | .045       | .03        | .05   | .025       | .04        | .065       | .05        | .065  | .03        | .06        |
| 3,500            | .05        | .035       | .06   | .03        | .05        | .08        | .06        | .085  | .04        | .07        |
| 4,000            | .06        | .04        | .07   | .035       | .06        | .10        | .065       | .105  | .045       | .085       |
| 4,500            | .07        | .04        | .08   | .04        | .07        | .11        | .08        | .12   | .05        | .11        |
| 5,000            | .08        | .05        | .10   | .045       | .08        | .125       | .09        | .135  | .06        | .115       |
| 5,500            | .09        | .055       | .12   | .05        | .09        | .14        | .095       | .150  | .065       | .13        |
| 6,000            | .10        | .06        | .13   | .055       | .10        | .16        | .10        | .175  | .075       | .15        |
| 6,500            | .11        | .06        | .14   | .055       | .11        | .17        | .11        | .185  | .075       | .16        |
| 7,000            | .12        | .07        | .15   | .06        | .12        | .18        | .12        | .20   | .085       | .175       |
| 7,500            | .13        | .075       | .155  | .065       | .13        | .20        | .13        | .225  | .095       | .19        |
| 8,000            | .14        | .08        | .16   | .07        | .14        | .21        | .14        | .25   | .10        | .20        |
| 8,500            | .15        | .085       | .17   | .075       | .15        | .225       | .145       | .255  | .11        | .215       |
| 9,000            | .16        | .09        | .18   | .08        | .16        | .24        | .155       | .275  | .12        | .225       |
| 9,500            | .17        | .095       | .195  | .085       | .17        | .25        | .160       | .285  | .125       | .245       |
| 10,000           | .18        | .10        | .20   | .09        | .175       | .26        | .17        | .305  | .13        | .255       |
| 10,500           | .19        | .105       | .21   | .095       | .18        | .275       | .185       | .325  | .14        | .265       |
| 11,000           | .195       | .11        | .22   | .10        | .19        | .29        | .19        | .345  | .145       | .275       |
| 11,500           | .20        | .115       | .235  | .105       | .20        | .305       | .20        | .355  | .15        | .30        |
| 12,000           | .21        | .115       | .245  | .11        | .21        | .32        | .205       | .375  | .16        | .305       |
| 12,500           | .22        | .12        | .255  | .115       | .22        | .335       | .21        | .390  | .17        | .32        |
| 13,000           | .23        | .125       | .265  | .12        | .225       | .35        | .225       | .415  | .175       | .34        |
| 13,500           | .235       | .13        | .27   | .125       | .235       | .365       | .235       | .425  | .18        | .355       |
| 14,000           | .25        | .14        | .29   | .13        | .25        | .38        | .245       | .44   | .19        | .365       |
| 14,500           | .255       | .145       | .30   | .135       | .26        | .395       | .25        | .455  | .20        | .38        |
| 15,000           | .265       | .15        | .31   | .14        | .265       | .41        | .26        | .475  | .205       | .395       |
| 15,500           | .27        | .155       | .32   | .145       | .27        | .425       | .27        | .495  | .215       | .405       |
| 16,000           | .28        | .16        | .33   | .15        | .28        | .44        | .275       | .505  | .22        | .42        |
| 16,500           | .29        | .16        | .34   | .16        | .29        | .455       | .285       | .525  | .23        | .445       |
| 17,000           | .295       | .17        | .35   | .165       | .29        | .47        | .29        | .545  | .245       | .45        |
| 17,500           | .30        | .175       | .36   | .165       | .31        | .485       | .30        | .555  | .245       | .465       |
| 18,000           | .31        | .18        | .37   | .175       | .315       | .50        | .305       | .575  | .25        | .475       |
| 18,500           | .32        | .185       | .39   | .175       | .32        | .515       | .313       | .595  | .26        | .485       |
| 19,000           | .33        | .19        | .395  | .18        | .33        | .53        | .32        | .605  | .265       | .50        |
| 19,500           | .34        | .195       | .40   | .18        | .34        | .545       | .33        | .625  | .275       | .51        |
| 20,000           | .35        | .20        | .42   | .185       | .35        | .555       | .345       | .645  | .28        | .53        |
| 20,500           | .....      | .....      | ..... | .....      | .....      | .565       | .35        | .655  | .285       | .545       |
| 21,000           | .....      | .....      | .43   | .....      | .....      | .580       | .360       | .675  | .305       | .56        |
| 21,500           | .....      | .....      | ..... | .....      | .....      | .59        | .37        | .695  | .305       | .57        |
| 22,000           | .....      | .....      | .45   | .....      | .....      | .605       | .375       | .705  | .31        | .58        |
| 22,500           | .....      | .....      | ..... | .....      | .....      | .625       | .38        | .725  | .32        | .595       |
| 23,000           | .....      | .....      | ..... | .....      | .....      | .645       | .395       | .745  | .325       | .61        |
| 23,500           | .....      | .....      | ..... | .....      | .....      | .65        | .40        | .765  | .335       | .625       |
| 24,000           | .....      | .....      | ..... | .....      | .....      | .665       | .41        | .780  | .34        | .64        |
| 25,000           | .....      | .....      | .51   | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 26,000           | .....      | .....      | .54   | .....      | .....      | .....      | .85        | ..... | .....      | .....      |
| 27,000           | .....      | .....      | .555  | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 28,000           | .....      | .....      | .57   | .....      | .....      | .....      | .90        | ..... | .....      | .....      |
| 30,000           | .....      | .....      | ..... | .....      | .....      | .....      | 1.00       | ..... | .....      | .....      |
| 31,000           | .....      | .....      | .66   | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 32,000           | .....      | .....      | .67   | .....      | .....      | .....      | 1.05       | ..... | .....      | .....      |
| 34,000           | .....      | .....      | .71   | .....      | .....      | .....      | 1.15       | ..... | .....      | .....      |
| 35,000           | .....      | .....      | .745  | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 36,000           | .....      | .....      | .76   | .....      | .....      | .....      | 1.2        | ..... | .....      | .....      |
| 38,000           | .....      | .....      | ..... | .....      | .....      | .....      | 1.27       | ..... | .....      | .....      |
| 40,000           | .....      | .....      | .86   | .....      | .....      | .....      | 1.34       | ..... | .....      | .....      |
| 41,000           | .....      | .....      | .90   | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 42,000           | .....      | .....      | ..... | .....      | .....      | .....      | 1.45       | ..... | .....      | .....      |
| 44,000           | .....      | .....      | .975  | .....      | .....      | .....      | 1.53       | ..... | .....      | .....      |
| 45,000           | .....      | .....      | 1.02  | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 46,000           | .....      | .....      | ..... | .....      | .....      | .....      | 1.60       | ..... | .....      | .....      |
| 47,000           | .....      | .....      | 1.07  | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 49,000           | .....      | .....      | 1.10  | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 51,000           | .....      | .....      | 1.15  | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 53,000           | .....      | .....      | 1.20  | .....      | .....      | .....      | .....      | ..... | .....      | .....      |
| 55,000           | .....      | .....      | 1.27  | .....      | .....      | .....      | .....      | ..... | .....      | .....      |

Breaking weight of Beam XXII = 55,400 lbs.  
" " " XXIII = 47,560 "

TABLE I.

| Loads<br>in<br>lbs | Deflections of Beams XXIV and XXV. |            |       |            |            |            |            |       |            |            |
|--------------------|------------------------------------|------------|-------|------------|------------|------------|------------|-------|------------|------------|
|                    | XXIV.                              |            |       |            |            | XXV.       |            |       |            |            |
|                    | 22<br>ins.                         | 44<br>ins. | Ends  | 44<br>ins. | 22<br>ins. | 24<br>ins. | 48<br>ins. | Ends  | 48<br>ins. | 24<br>ins. |
| 500                | .....                              | .....      | ..... | .....      | .....      | .01        | .005       | .01   | .005       | .01        |
| 1,000              | .....                              | .....      | ..... | .....      | .....      | .015       | .01        | .015  | .005       | .015       |
| 2,000              | .....                              | .....      | ..... | .....      | .....      | .02        | .015       | .03   | .01        | .02        |
| 3,000              | .....                              | .....      | ..... | .....      | .....      | .04        | .025       | .05   | .015       | .04        |
| 4,000              | .....                              | .....      | ..... | .....      | .....      | .06        | .035       | .075  | .025       | .06        |
| 5,000              | .045                               | .03        | .05   | .04        | .04        | .075       | .045       | .095  | .04        | .08        |
| 6,000              | .065                               | .04        | .065  | .045       | .055       | .095       | .055       | .105  | .045       | .10        |
| 7,000              | .08                                | .04        | .08   | .05        | .06        | .115       | .065       | .140  | .055       | .115       |
| 8,000              | .10                                | .05        | .10   | .06        | .08        | .125       | .07        | .15   | .065       | .125       |
| 9,000              | .105                               | .055       | .105  | .07        | .08        | .14        | .08        | .18   | .075       | .14        |
| 10,000             | .12                                | .06        | .12   | .07        | .095       | .155       | .09        | .195  | .08        | .155       |
| 11,000             | .13                                | .07        | .13   | .08        | .11        | .17        | .10        | .225  | .085       | .165       |
| 12,000             | .14                                | .08        | .15   | .085       | .125       | .185       | .105       | .245  | .10        | .18        |
| 13,000             | .145                               | .085       | .16   | .09        | .14        | .205       | .115       | .26   | .105       | .21        |
| 14,000             | .16                                | .09        | .17   | .10        | .15        | .215       | .12        | .285  | .115       | .22        |
| 15,000             | .18                                | .10        | .20   | .11        | .165       | .24        | .125       | .30   | .125       | .235       |
| 16,000             | .20                                | .105       | .21   | .12        | .17        | .255       | .14        | .325  | .13        | .255       |
| 17,000             | .21                                | .11        | .22   | .125       | .18        | .265       | .15        | .345  | .145       | .265       |
| 18,000             | .22                                | .12        | .25   | .13        | .19        | .285       | .155       | .365  | .16        | .28        |
| 19,000             | .225                               | .125       | .25   | .14        | .205       | .30        | .16        | .395  | .17        | .305       |
| 20,000             | .24                                | .13        | .26   | .15        | .22        | .315       | .17        | .410  | .18        | .315       |
| 21,000             | .26                                | .14        | .27   | .16        | .24        | .340       | .185       | .445  | .19        | .335       |
| 22,000             | .27                                | .145       | .29   | .17        | .25        | .355       | .195       | .465  | .20        | .355       |
| 23,000             | .28                                | .15        | .31   | .175       | .26        | .....      | .....      | ..... | .....      | .....      |
| 24,000             | .30                                | .16        | .32   | .18        | .27        | .....      | .....      | .50   | .....      | .....      |
| 25,000             | .31                                | .17        | .335  | .185       | .275       | .....      | .....      | ..... | .....      | .....      |
| 25,800             | ....                               | ....       | ....  | ....       | ....       | .....      | .....      | .54   | .....      | .....      |
| 26,000             | .32                                | .175       | .35   | .195       | .29        | .....      | .....      | ..... | .....      | .....      |
| 27,000             | .34                                | .18        | .36   | .205       | .31        | .....      | .....      | ..... | .....      | .....      |
| 28,000             | .36                                | .18        | .38   | .21        | .32        | .....      | .....      | ..... | .....      | .....      |
| 29,000             | .37                                | .19        | .40   | .22        | .33        | .....      | .....      | ..... | .....      | .....      |
| 30,000             | .38                                | .20        | .415  | .225       | .34        | .....      | .....      | ..... | .....      | .....      |
| 30,200             | ....                               | ....       | ....  | ....       | ....       | .....      | .....      | .65   | .....      | .....      |
| 31,000             | .39                                | .21        | .425  | .235       | .355       | .....      | .....      | ..... | .....      | .....      |
| 32,000             | .405                               | .22        | .45   | .24        | .37        | .....      | .....      | ..... | .....      | .....      |
| 33,000             | ....                               | ....       | .46   | ....       | ....       | .....      | .....      | .75   | .....      | .....      |
| 33,200             | ....                               | ....       | ....  | ....       | ....       | .....      | .....      | ..... | .....      | .....      |
| 34,000             | ....                               | ....       | .48   | ....       | ....       | .....      | .....      | ..... | .....      | .....      |
| 36,000             | ....                               | ....       | .51   | ....       | ....       | .....      | .....      | ..... | .....      | .....      |
| 37,000             | ....                               | ....       | .54   | ....       | ....       | .....      | .....      | ..... | .....      | .....      |
| 38,000             | ....                               | ....       | .56   | ....       | ....       | .....      | .....      | ..... | .....      | .....      |
| 39,000             | ....                               | ....       | .575  | ....       | ....       | .....      | .....      | ..... | .....      | .....      |
| 39,700             | ....                               | ....       | ....  | ....       | ....       | .....      | .....      | .95   | ....       | ....       |
| 40,000             | ....                               | ....       | .66   | ....       | ....       | .....      | .....      | ....  | ....       | ....       |

Breaking weight of Beam XXIV = 76,900 lbs. for beam of reduced length.

Breaking weight of Beam XXV = 42,900 lbs.

Table J showing deflections in inches of two Douglas Fir planks under gradually increased loads.

| Loads<br>in lbs. | Deflections<br>in ins. of<br>Plank 1. |       | Deflections<br>in ins. of<br>Plank 2. |       |
|------------------|---------------------------------------|-------|---------------------------------------|-------|
|                  | Ends.                                 | Ends. | Ends.                                 | Ends. |
| 2,000            | .05                                   | .06   | .....                                 | ..... |
| 3,000            | .07                                   | .10   | .....                                 | ..... |
| 4,000            | .10                                   | .15   | .....                                 | ..... |
| 5,000            | .12                                   | .19   | .....                                 | ..... |
| 6,000            | .15                                   | .23   | .....                                 | ..... |
| 7,000            | .16                                   | .27   | .....                                 | ..... |
| 8,000            | .18                                   | .35   | .....                                 | ..... |
| 9,000            | .21                                   | ....  | .....                                 | ..... |

Breaking weight of Plank 1 = 22,250 lbs.  
 " " " 2 = 13,250 "

Tables K to M shew deflections in inches of Canadian New Red Pine Beams.

TABLE K.

| Louds<br>in<br>lbs. | Deflections of Beams XXVI to XXVIII. |         |       |         |        |         |       |
|---------------------|--------------------------------------|---------|-------|---------|--------|---------|-------|
|                     | XXVI.                                |         |       |         | XXVII. | XXVIII. |       |
|                     | 35 ins.                              | 70 ins. | Ends. | 70 ins. |        |         |       |
| 1,000               | .055                                 | .035    | .065  | .04     | .055   | .08     | .09   |
| 1,500               | .110                                 | .060    | .135  | .060    | .110   | .15     | .15   |
| 1,800               | .145                                 | .080    | .175  | .080    | .150   | .....   | ..... |
| 2,000               | .165                                 | .095    | .200  | .09     | .165   | .20     | .225  |
| 2,300               | .195                                 | .110    | .235  | .110    | .200   | .....   | ..... |
| 2,500               | .215                                 | .125    | .260  | .125    | .215   | .26     | .300  |
| 2,700               | .235                                 | .130    | .285  | .130    | .240   | .....   | ..... |
| 3,000               | .265                                 | .150    | .320  | .150    | .265   | .32     | .36   |
| 3,200               | .290                                 | .160    | .350  | .160    | .295   | .....   | ..... |
| 3,500               | .320                                 | .180    | .385  | .180    | .320   | .37     | .44   |
| 3,700               | .345                                 | .195    | .410  | .195    | .350   | .....   | ..... |
| 4,000               | .370                                 | .210    | .450  | .210    | .370   | .44     | .50   |
| 4,200               | .395                                 | .225    | .475  | .225    | .400   | .....   | ..... |
| 4,500               | .430                                 | .245    | .510  | .245    | .430   | .49     | .575  |
| 4,700               | .450                                 | .255    | .535  | .250    | .450   | .....   | ..... |
| 5,000               | .480                                 | .270    | .570  | .265    | .475   | .55     | .65   |
| 5,200               | .500                                 | .280    | .600  | .275    | .500   | .....   | ..... |
| 5,500               | .535                                 | .295    | .635  | .290    | .530   | .60     | .72   |
| 5,700               | .560                                 | .310    | .660  | .305    | .550   | .....   | ..... |
| 6,000               | .580                                 | .330    | .700  | .320    | .580   | .66     | .79   |
| 6,200               | .605                                 | .340    | .725  | .335    | .600   | .....   | ..... |
| 6,500               | .635                                 | .360    | .755  | .350    | .635   | .73     | .86   |
| 6,700               | .655                                 | .370    | .790  | .365    | .655   | .....   | ..... |
| 7,000               | .690                                 | .385    | .825  | .380    | .685   | .79     | .93   |
| 7,200               | .715                                 | .395    | .855  | .390    | .705   | .....   | ..... |
| 7,500               | .745                                 | .415    | .890  | .410    | .740   | .85     | 1.00  |
| 7,700               | .765                                 | .425    | .915  | .425    | .755   | .....   | ..... |
| 8,000               | .800                                 | .445    | .950  | .440    | .800   | .92     | 1.07  |
| 8,200               | .820                                 | .455    | .980  | .455    | .815   | .....   | ..... |
| 8,500               | .850                                 | .475    | 1.020 | .470    | .855   | .99     | 1.14  |
| 8,700               | .880                                 | .495    | 1.050 | .485    | .875   | .....   | ..... |
| 9,000               | .915                                 | .510    | 1.100 | .510    | .915   | 1.05    | 1.21  |
| 9,200               | .945                                 | .525    | 1.135 | .525    | .945   | .....   | ..... |
| 9,500               | .995                                 | .545    | 1.185 | .545    | .985   | 1.13    | 1.28  |
| 9,700               | 1.015                                | .560    | 1.225 | .560    | 1.010  | .....   | ..... |
| 10,000              | 1.050                                | .585    | 1.265 | .580    | 1.050  | 1.20    | 1.36  |
| 10,500              | .....                                | .....   | ..... | .....   | .....  | .....   | 1.43  |
| 11,000              | .....                                | .....   | 1.400 | .....   | .....  | 1.36    | 1.50  |
| 11,500              | .....                                | .....   | ..... | .....   | .....  | .....   | 1.57  |
| 12,000              | .....                                | .....   | 1.600 | .....   | .....  | 1.51    | 1.66  |
| 12,500              | .....                                | .....   | ..... | .....   | .....  | .....   | 1.72  |
| 13,000              | .....                                | .....   | 1.700 | .....   | .....  | 1.63    | 1.80  |
| 13,500              | .....                                | .....   | ..... | .....   | .....  | .....   | 1.87  |
| 13,800              | .....                                | .....   | ..... | .....   | .....  | .....   | ..... |
| 14,000              | .....                                | .....   | 2.050 | .....   | .....  | .....   | 1.95  |
| 14,500              | .....                                | .....   | ..... | .....   | .....  | .....   | 2.06  |
| 15,000              | .....                                | .....   | ..... | .....   | .....  | 2.00    | 2.15  |
| 15,500              | .....                                | .....   | ..... | .....   | .....  | .....   | 2.30  |
| 15,600              | .....                                | .....   | 2.750 | .....   | .....  | .....   | ..... |
| 16,000              | .....                                | .....   | 3.000 | .....   | .....  | 2.20    | 2.44  |
| 16,500              | .....                                | .....   | ..... | .....   | .....  | .....   | ..... |
| 17,000              | .....                                | .....   | ..... | .....   | .....  | 2.52    | ..... |
| 17,050              | .....                                | .....   | ..... | .....   | .....  | .....   | 2.80  |

Breaking weight of Beam XXVI = 16,940 lbs.

" " " XXVII = 17,700 "

" " " XXVIII = 17,050 "

TABLE L.

| Loads<br>in<br>lbs. | Deflections of Beams XXIX to XXXII. |         |       |         |         |       |       |        |
|---------------------|-------------------------------------|---------|-------|---------|---------|-------|-------|--------|
|                     | XXIX.                               |         |       |         | XXX.    |       | XXXI. | XXXII. |
|                     | 35 ins.                             | 70 ins. | Ends. | 70 ins. | 35 ins. | Ends. | Ends. | Ends.  |
| 200                 | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | .035   |
| 500                 | .030                                | .015    | .04   | .015    | .020    | .130  | ...   | .185   |
| 600                 | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | .235   |
| 700                 | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | .290   |
| 800                 | ...                                 | ...     | ...   | ...     | ...     | .245  | ...   | .340   |
| 900                 | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | .385   |
| 1,000               | .120                                | .050    | .140  | .070    | .100    | .320  | .29   | .430   |
| 1,100               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | .495   |
| 1,200               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | .545   |
| 1,300               | ...                                 | ...     | ...   | ...     | ...     | .440  | .385  | .600   |
| 1,400               | .185                                | .090    | .225  | .110    | .190    | ...   | ...   | .650   |
| 1,500               | ...                                 | ...     | ...   | ...     | ...     | .505  | .450  | .700   |
| 1,600               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | .750   |
| 1,700               | ...                                 | ...     | ...   | ...     | ...     | .590  | .520  | .800   |
| 1,800               | .265                                | .135    | .310  | .150    | .250    | ...   | ...   | .855   |
| 1,900               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | .915   |
| 2,000               | .300                                | .150    | .350  | .170    | .290    | .710  | .615  | .960   |
| 2,100               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.015  |
| 2,200               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.075  |
| 2,300               | ...                                 | ...     | ...   | ...     | ...     | .835  | .725  | 1.145  |
| 2,400               | .370                                | .190    | .440  | .205    | .360    | ...   | ...   | 1.195  |
| 2,500               | ...                                 | ...     | ...   | ...     | ...     | .905  | .780  | 1.245  |
| 2,600               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.300  |
| 2,700               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.360  |
| 2,800               | .440                                | .235    | .525  | .250    | .435    | 1.040 | .900  | 1.410  |
| 2,900               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.465  |
| 3,000               | .480                                | .250    | .565  | .265    | .460    | 1.150 | .960  | 1.525  |
| 3,100               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.585  |
| 3,200               | ...                                 | ...     | ...   | ...     | ...     | 1.210 | 1.035 | 1.625  |
| 3,300               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.700  |
| 3,400               | .550                                | .295    | .650  | .305    | .540    | ...   | ...   | 1.750  |
| 3,500               | ...                                 | ...     | ...   | ...     | ...     | 1.340 | 1.115 | 1.800  |
| 3,600               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.865  |
| 3,700               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 1.935  |
| 3,800               | .620                                | .330    | .740  | .350    | .610    | 1.456 | 1.225 | 1.990  |
| 3,900               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 2.025  |
| 4,000               | .640                                | .350    | .775  | .365    | .640    | 1.550 | 1.320 | 2.100  |
| 4,100               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 2.170  |
| 4,200               | ...                                 | ...     | ...   | ...     | ...     | 1.640 | ...   | 2.220  |
| 4,300               | ...                                 | ...     | ...   | ...     | ...     | ...   | 1.445 | 2.290  |
| 4,400               | .740                                | .390    | .865  | .410    | .730    | ...   | ...   | 2.355  |
| 4,500               | ...                                 | ...     | ...   | ...     | ...     | 1.765 | 1.510 | 2.420  |
| 4,600               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 2.470  |
| 4,700               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 2.530  |
| 4,800               | .810                                | .445    | .960  | .450    | .800    | 1.900 | 1.615 | 2.610  |
| 4,900               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 2.680  |
| 5,000               | .850                                | .460    | 1.000 | .470    | .835    | 2.010 | 1.700 | 2.755  |
| 5,100               | ...                                 | ...     | ...   | ...     | ...     | ...   | ...   | 2.830  |
| 5,200               | ...                                 | ...     | ...   | ...     | ...     | 2.120 | ...   | ...    |
| 5,300               | ...                                 | ...     | ...   | ...     | ...     | ...   | 1.815 | ...    |
| 5,400               | .910                                | .500    | 1.085 | .515    | .900    | ...   | ...   | ...    |
| 5,500               | ...                                 | ...     | ...   | ...     | ...     | 2.335 | 1.895 | ...    |
| 5,700               | ...                                 | ...     | ...   | ...     | ...     | 2.515 | ...   | ...    |
| 5,800               | .985                                | .545    | 1.175 | .560    | .990    | ...   | ...   | ...    |
| 6,000               | 1.030                               | .565    | 1.225 | .580    | 1.005   | 2.900 | 2.115 | ...    |
| 6,400               | 1.110                               | .610    | 1.320 | .620    | 1.100   | ...   | ...   | ...    |
| 6,500               | ...                                 | ...     | ...   | ...     | ...     | ...   | 2.410 | ...    |
| 6,800               | 1.170                               | .640    | 1.405 | .660    | 1.175   | ...   | ...   | ...    |
| 7,000               | 1.220                               | .665    | 1.455 | .675    | 1.210   | ...   | ...   | ...    |
| 7,400               | 1.290                               | .715    | 1.555 | .740    | 1.300   | ...   | ...   | ...    |
| 7,800               | 1.360                               | .755    | 1.660 | .775    | 1.360   | ...   | ...   | ...    |
| 8,000               | 1.410                               | .785    | 1.710 | .800    | 1.410   | ...   | ...   | ...    |
| 8,400               | 1.500                               | .830    | 1.810 | .850    | 1.510   | ...   | ...   | ...    |
| 8,800               | 1.590                               | .880    | 1.915 | .900    | 1.580   | ...   | ...   | ...    |
| 9,000               | 1.640                               | .910    | 2.005 | .930    | 1.650   | ...   | ...   | ...    |
| 10,000              | ...                                 | ...     | 2.270 | ...     | ...     | ...   | ...   | ...    |
| 11,000              | ...                                 | ...     | 2.650 | ...     | ...     | ...   | ...   | ...    |

Breaking weight of Beam XXIX = 11,960 lbs.

" " " XXX = 5,700 "

" " " XXXI = 6,500 "

" " " XXXII = 5,200 "

TABLE M.

| Loads in<br>lbs. | Deflections of Beams XXXIII to XXXV. |       |        |
|------------------|--------------------------------------|-------|--------|
|                  | XXXIII.                              |       | XXXIV. |
|                  | Ends.                                | Ends. | Ends.  |
| 500              | .065                                 | .080  | .030   |
| 800              | .....                                | .145  | .065   |
| 1,000            | .160                                 | .185  | .090   |
| 1,200            | .205                                 | .230  | .125   |
| 1,400            | .250                                 | .275  | .150   |
| 1,600            | .275                                 | .320  | .175   |
| 1,800            | .325                                 | .360  | .195   |
| 2,000            | .375                                 | .405  | .220   |
| 2,200            | .410                                 | .450  | .245   |
| 2,400            | .465                                 | .490  | .270   |
| 2,600            | .500                                 | .535  | .295   |
| 2,800            | .540                                 | .580  | .320   |
| 3,000            | .585                                 | .625  | .345   |
| 3,200            | .630                                 | .670  | .370   |
| 3,400            | .670                                 | .715  | .390   |
| 3,600            | .710                                 | .760  | .415   |
| 3,800            | .750                                 | .810  | .445   |
| 4,000            | .790                                 | .850  | .465   |
| 4,200            | .830                                 | .900  | .490   |
| 4,400            | .870                                 | .945  | .515   |
| 4,600            | .910                                 | .990  | .545   |
| 4,800            | .950                                 | 1.035 | .565   |
| 5,000            | 1.000                                | 1.080 | .590   |
| 5,200            | 1.040                                | 1.125 | .615   |
| 5,400            | 1.090                                | 1.175 | .640   |
| 5,600            | 1.125                                | 1.220 | .670   |
| 5,800            | 1.165                                | ..... | .695   |
| 6,000            | 1.220                                | ..... | .720   |
| 6,200            | 1.260                                | ..... | .745   |
| 6,400            | 1.310                                | ..... | .770   |
| 6,600            | 1.355                                | ..... | .800   |
| 6,800            | 1.415                                | ..... | .830   |
| 7,000            | 1.455                                | ..... | .860   |
| 7,200            | 1.545                                | ..... | .885   |
| 7,400            | 1.590                                | ..... | .915   |
| 7,600            | 1.640                                | ..... | .950   |
| 7,800            | 1.690                                | ..... | .....  |
| 8,200            | 1.790                                | ..... | .....  |

Breaking weight of Beam XXXIII = 9,250 lbs.

" " " XXXIV = 5,600 "

" " " XXXV = 7,600 "

Tables N to Q show deflections in inches of Canadian New White Pine Beams.

TABLE N.

| Loads in<br>lbs. | Deflections of Beams XXXVI to XLII. |            |            |               |            |            |             |          |       |       |       |       |
|------------------|-------------------------------------|------------|------------|---------------|------------|------------|-------------|----------|-------|-------|-------|-------|
|                  | XXXVI.                              |            |            |               |            | XXXVII.    |             | XXXVIII. |       | XXXIX | XL    | XLII. |
|                  | 108<br>ins.                         | 72<br>ins. | 36<br>ins. | Ends.<br>ins. | 36<br>ins. | 72<br>ins. | 108<br>ins. | Ends.    | Ends. | Ends. | Ends. | Ends. |
| 5000             | .109                                | .30        | .30        | .32           | .30        | .29        | .109        | .....    | ..... | ..... | ..... | ..... |
| 7500             | .375                                | .70        | .93        | 1.02          | .90        | .66        | .344        | .....    | ..... | ..... | ..... | ..... |
| 10000            | .594                                | 1.00       | 1.33       | 1.45          | 1.29       | .95        | .516        | .....    | .10   | .11   | .11   | .13   |
| 11000            | .719                                | 1.34       | 1.78       | 1.95          | 1.74       | 1.28       | .688        | .....    | ..... | ..... | ..... | ..... |
| 12500            | .799                                | 1.47       | 1.96       | 2.16          | 1.93       | 1.42       | .750        | .....    | .125  | .14   | ..... | ..... |
| 15000            | .906                                | 1.68       | 2.24       | 2.45          | 2.20       | 1.62       | .875        | .....    | .15   | .165  | .17   | .20   |
| 17500            | 1.125                               | 2.05       | 2.70       | 2.97          | 2.65       | 1.96       | 1.047       | .....    | .19   | .19   | ..... | ..... |
| 20000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | .21   | .2255 | .23   | .29   |
| 22000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | ..... | .25   | .32   | ..... |
| 22500            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | .245  | .2555 | ..... | ..... |
| 24000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | ..... | ..... | .27   | .35   |
| 25000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | .27   | .285  | ..... | ..... |
| 26000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | ..... | ..... | .30   | .40   |
| 27500            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | .30   | .31   | ..... | ..... |
| 28000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | ..... | ..... | .33   | .44   |
| 30000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | .33   | .35   | .36   | .49   |
| 32000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | ..... | ..... | .39   | .53   |
| 32500            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | .37   | ..... | ..... | ..... |
| 34000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | ..... | ..... | .42   | ..... |
| 36000            | .....                               | .....      | .....      | .....         | .....      | .....      | .....       | .....    | ..... | ..... | .45   | ..... |

Breaking weight of Beam XXXIV = 19,600 lbs.

" " " XXXV = 24,000 "

" " " XXXVI = 52,450 "

" " " XXXVII = 51,400 "

TABLE O.

| Loads in lbs | Deflections of Beams XL to XLII. |        |        |       |         |        |         |       |       |
|--------------|----------------------------------|--------|--------|-------|---------|--------|---------|-------|-------|
|              | XLII.                            |        |        |       |         |        | XLIII.  | XLIV. |       |
|              | 108 ins                          | 72 ins | 36 ins | Ends. | 36 ins. | 72 ins | 108 ins | Ends. | Ends. |
| 2500         | .0312                            | .05    | .07    | .08   | .07     | .055   | .031    | ..... | ..... |
| 3000         | .047                             | .095   | .14    | .15   | .14     | .10    | .047    | ..... | ..... |
| 3500         | .078                             | .13    | .18    | .19   | .18     | .13    | .078    | ..... | ..... |
| 4000         | .094                             | .17    | .24    | .26   | .24     | .17    | .109    | ..... | ..... |
| 4500         | .109                             | .20    | .27    | .30   | .28     | .205   | .125    | ..... | ..... |
| 5000         | .125                             | .245   | .33    | .37   | .34     | .25    | .141    | ..... | ..... |
| 5500         | .141                             | .275   | .38    | .42   | .39     | .28    | .156    | ..... | ..... |
| 6000         | .172                             | .325   | .44    | .47   | .45     | .33    | .172    | ..... | ..... |
| 6500         | .187                             | .35    | .49    | .53   | .49     | .35    | .188    | ..... | ..... |
| 7000         | .219                             | .39    | .54    | .60   | .54     | .40    | .219    | ..... | ..... |
| 7500         | .234                             | .425   | .59    | .65   | .60     | .43    | .234    | ..... | ..... |
| 8000         | .250                             | .47    | .64    | .71   | .65     | .47    | .266    | ..... | ..... |
| 8500         | .281                             | .505   | .69    | .76   | .70     | .52    | .281    | ..... | ..... |
| 9000         | .297                             | .54    | .75    | .82   | .75     | .55    | .312    | ..... | ..... |
| 9500         | .312                             | .59    | .80    | .90   | .81     | .60    | .328    | ..... | ..... |
| 10000        | .328                             | .61    | .84    | .93   | .85     | .63    | .344    | .10   | .11   |
| 10500        | .359                             | .66    | .91    | 1.00  | .91     | .67    | .359    | ..... | ..... |
| 11000        | .375                             | .70    | .97    | 1.07  | .96     | .71    | .375    | ..... | ..... |
| 11500        | .406                             | .75    | 1.03   | 1.14  | 1.04    | .76    | .406    | ..... | ..... |
| 12000        | .422                             | .77    | 1.06   | 1.17  | 1.07    | .79    | .422    | ..... | ..... |
| 12500        | .438                             | .80    | 1.11   | 1.21  | 1.11    | .82    | .438    | ..... | ..... |
| 13000        | .453                             | .835   | 1.16   | 1.30  | 1.17    | .875   | .453    | ..... | ..... |
| 13500        | .484                             | .905   | 1.24   | 1.37  | 1.25    | .93    | .484    | ..... | ..... |
| 14000        | .500                             | .945   | 1.29   | 1.44  | 1.31    | .97    | .510    | ..... | ..... |
| 14500        | .531                             | .975   | 1.34   | 1.49  | 1.355   | 1.00   | .531    | ..... | ..... |
| 15000        | .547                             | 1.02   | 1.40   | 1.55  | 1.415   | 1.02   | .562    | .16   | .16   |
| 15500        | .562                             | 1.06   | 1.45   | 1.61  | 1.48    | 1.10   | .578    | ..... | ..... |
| 16000        | .593                             | 1.105  | 1.51   | 1.68  | 1.53    | 1.15   | .593    | ..... | ..... |
| 16500        | .609                             | 1.15   | 1.57   | 1.76  | 1.60    | 1.19   | .625    | ..... | ..... |
| 17000        | .641                             | 1.19   | 1.63   | 1.81  | 1.65    | 1.23   | .641    | ..... | ..... |
| 17500        | .656                             | 1.23   | 1.68   | 1.87  | 1.705   | 1.27   | .672    | ..... | ..... |
| 18000        | .687                             | 1.27   | 1.75   | 1.96  | 1.775   | 1.32   | .687    | ..... | ..... |
| 18500        | .719                             | 1.34   | 1.84   | 2.05  | 1.86    | 1.39   | .734    | ..... | ..... |
| 19000        | .750                             | 1.38   | 1.89   | 2.11  | 1.92    | 1.43   | .750    | ..... | ..... |
| 19500        | .766                             | 1.43   | 1.95   | 2.19  | 1.98    | 1.47   | .766    | ..... | ..... |
| 20000        | .781                             | 1.48   | 2.02   | 2.27  | 2.05    | 1.52   | .797    | .23   | .24   |
| 20500        | .813                             | 1.53   | 2.10   | 2.35  | 2.13    | 1.58   | .828    | ..... | ..... |
| 21000        | .844                             | 1.58   | 2.16   | 2.42  | 2.19    | 1.62   | .859    | ..... | ..... |
| 21500        | .875                             | 1.665  | 2.28   | 2.55  | 2.31    | 1.70   | .891    | ..... | ..... |
| 22000        | .924                             | 1.72   | 2.36   | 2.65  | 2.39    | 1.77   | .938    | ..... | ..... |
| 25000        | ....                             | ....   | ....   | ....  | ....    | ....   | ....    | .29   | .30   |

Breaking weight of Beam XXXVIII = 26,350 lbs.

" " " XXXIX = 48,600 "

" " " XL = 51,870 "

TABLE P.

## Deflections of Beams XLV to XLVII.

| Loads in lbs. | XLV.     |         |         |               |         |          | XLVI. | XLVII. |
|---------------|----------|---------|---------|---------------|---------|----------|-------|--------|
|               | 108 ins. | 72 ins. | 36 ins. | Ends, 36 ins. | 72 ins. | 108 ins. |       |        |
| 2500          | .125     | .22     | .30     | .34           | .29     | .21      | .141  | .02    |
| 3000          | .141     | .27     | .35     | .39           | .34     | .31      | .156  | .....  |
| 3500          | .172     | .29     | .41     | .45           | .39     | .34      | .188  | .....  |
| 4000          | .188     | .34     | .45     | .50           | .44     | .36      | .203  | .....  |
| 4500          | .203     | .37     | .50     | .55           | .49     | .44      | .219  | .....  |
| 5000          | .219     | .42     | .55     | .61           | .54     | .44      | .234  | .....  |
| 5500          | .234     | .45     | .60     | .67           | .59     | .47      | .250  | .....  |
| 6000          | .250     | .49     | .65     | .73           | .64     | .51      | .266  | .....  |
| 6500          | .266     | .53     | .71     | .79           | .69     | .56      | .281  | .....  |
| 7000          | .297     | .56     | .76     | .84           | .74     | .59      | .312  | .....  |
| 7500          | .312     | .60     | .81     | .90           | .79     | .62      | .328  | .....  |
| 8000          | .344     | .63     | .86     | .95           | .85     | .66      | .344  | .....  |
| 8500          | .359     | .67     | .92     | 1.03          | .90     | .69      | .359  | .....  |
| 9000          | .375     | .71     | .97     | 1.08          | .95     | .74      | .391  | .....  |
| 9500          | .391     | .75     | 1.02    | 1.14          | 1.00    | .78      | .406  | .....  |
| 10000         | .422     | .79     | 1.08    | 1.20          | 1.06    | .81      | .422  | .12    |
| 10500         | .438     | .83     | 1.14    | 1.26          | 1.11    | .86      | .438  | .....  |
| 11000         | .453     | .87     | 1.20    | 1.33          | 1.17    | .90      | ..... | .....  |
| 11500         | .484     | .92     | 1.26    | 1.40          | 1.24    | .95      | .500  | .....  |
| 12000         | .500     | .96     | 1.31    | 1.47          | 1.28    | .98      | .516  | .....  |
| 12500         | .531     | 1.01    | 1.36    | 1.53          | 1.34    | 1.02     | .531  | .13    |
| 13000         | .547     | 1.05    | 1.42    | 1.59          | 1.39    | 1.06     | .547  | .....  |
| 13500         | .563     | 1.08    | 1.48    | 1.66          | 1.45    | 1.10     | .578  | .....  |
| 14000         | .593     | 1.13    | 1.55    | 1.73          | 1.51    | 1.15     | .593  | .....  |
| 14500         | .625     | 1.17    | 1.60    | 1.79          | 1.57    | 1.18     | .625  | .....  |
| 15000         | .641     | 1.21    | 1.65    | 1.86          | 1.62    | 1.22     | .641  | .20    |
| 15500         | .656     | 1.25    | 1.71    | 1.93          | 1.69    | 1.27     | .656  | .....  |
| 16000         | .687     | 1.30    | 1.78    | 2.00          | 1.75    | 1.31     | .672  | .....  |
| 16500         | .703     | 1.35    | 1.85    | 2.08          | 1.82    | 1.36     | .687  | .....  |
| 17000         | .734     | 1.39    | 1.90    | 2.14          | 1.86    | 1.40     | .734  | .....  |
| 17500         | .766     | 1.43    | 1.97    | 2.22          | 1.94    | 1.45     | .750  | .20    |
| 18000         | .781     | 1.50    | 2.05    | 2.33          | 2.02    | 1.51     | .781  | .....  |
| 18500         | .797     | 1.54    | 2.11    | 2.39          | 2.08    | 1.56     | .797  | .....  |
| 19000         | .828     | 1.59    | 2.19    | 2.48          | 2.15    | 1.60     | .828  | .....  |
| 20000         | .875     | 1.68    | 2.31    | 2.63          | 2.29    | 1.70     | .875  | .26    |
| 20500         | .924     | 1.75    | 2.41    | 2.76          | 2.38    | 1.77     | .924  | .....  |
| 21000         | .953     | 1.82    | 2.50    | 2.88          | 2.47    | 1.83     | .953  | .....  |
| 22500         | .....    | .....   | .....   | .....         | .....   | .....    | ..... | .26    |
| 25000         | .....    | .....   | .....   | .....         | .....   | .....    | .35   | .30    |
| 27500         | .....    | .....   | .....   | .....         | .....   | .....    | ..... | .34    |
| 30000         | .....    | .....   | .....   | .....         | .....   | .....    | ..... | .39    |

Breaking weight of Beam XLI = 24,850 lbs.

" " " XLII = 41,400 "

" " " XLIII = 48,650 "

TABLE Q.

| Load in lbs. | Deflections of Beams XLVIII to L. |      |             |             |      |             |             |      |             |  |
|--------------|-----------------------------------|------|-------------|-------------|------|-------------|-------------|------|-------------|--|
|              | XLVIII.                           |      |             | XLIX.       |      |             | L.          |      |             |  |
|              | 37½<br>ins.                       | Ends | 37½<br>ins. | 37½<br>ins. | Ends | 37½<br>ins. | 46½<br>ins. | Ends | 46½<br>ins. |  |
| 1000         | .01                               | .01  | .01         | .005        | .01  | .005        | .015        | .015 | .01         |  |
| 2000         | .025                              | .03  | .02         | .02         | .04  | .02         | .04         | .055 | .035        |  |
| 3000         | .04                               | .05  | .035        | .035        | .06  | .035        | .07         | .105 | .065        |  |
| 4000         | .055                              | .065 | .052        | .05         | .08  | .05         | .10         | .15  | .10         |  |
| 5000         | .065                              | .085 | .06         | .065        | .10  | .065        | .135        | .195 | .135        |  |
| 6000         | .08                               | .105 | .075        | .075        | .125 | .08         | .165        | .245 | .165        |  |
| 7000         | .10                               | .125 | .08         | .095        | .15  | .095        | .20         | .295 | .20         |  |
| 8000         | .105                              | .15  | .103        | .11         | .17  | .105        | .22         | .33  | .225        |  |
| 9000         | .12                               | .17  | .11         | .125        | .20  | .13         | .25         | .375 | .255        |  |
| 10000        | .135                              | .195 | .125        | .14         | .22  | .14         | .28         | .43  | .28         |  |
| 10500        | .14                               | .215 | .135        | ...         | ...  | ...         | ...         | ...  | ...         |  |
| 11000        | .15                               | .22  | .143        | .155        | .25  | .15         | .30         | .46  | .30         |  |
| 11500        | .155                              | .23  | .15         | ...         | ...  | ...         | ...         | ...  | ...         |  |
| 12000        | .165                              | .24  | .155        | .175        | .265 | .165        | .33         | .50  | .33         |  |
| 12500        | .175                              | .25  | .16         | .18         | .275 | .17         | .35         | .53  | .35         |  |
| 13000        | .18                               | .265 | .165        | .19         | .29  | .185        | .36         | .55  | .36         |  |
| 13500        | .185                              | .27  | .17         | .20         | .30  | .195        | .375        | .57  | .375        |  |
| 14000        | .19                               | .285 | .177        | .21         | .315 | .20         | .39         | .60  | .39         |  |
| 14500        | .20                               | .295 | .19         | .215        | .32  | .21         | .41         | .615 | .40         |  |
| 15000        | .21                               | .305 | .20         | .22         | .35  | .215        | .42         | .645 | .42         |  |
| 15500        | .215                              | .32  | .205        | .225        | .355 | .22         | .43         | .655 | .43         |  |
| 16000        | .22                               | .33  | .21         | .235        | .365 | .23         | .445        | .67  | .45         |  |
| 16500        | .23                               | .34  | .223        | .245        | .375 | .24         | .46         | .70  | .46         |  |
| 17000        | .235                              | .355 | .23         | .25         | .39  | .25         | .475        | .72  | .475        |  |
| 17500        | .24                               | .365 | .235        | .26         | .405 | .255        | .49         | .745 | .50         |  |
| 18000        | .25                               | .38  | .24         | .27         | .415 | .26         | .51         | .76  | .51         |  |
| 18500        | .25                               | .395 | .25         | .275        | .425 | .27         | .525        | .795 | .52         |  |
| 19000        | .265                              | .405 | .255        | .285        | .44  | .28         | .54         | .82  | .55         |  |
| 19500        | .27                               | .415 | .26         | .295        | .455 | .29         | .55         | .84  | .56         |  |
| 20000        | .275                              | .425 | .27         | .30         | .465 | .30         | .57         | .865 | .58         |  |
| 20500        | .285                              | .445 | .285        | .31         | .475 | .31         | .585        | .895 | .59         |  |
| 21000        | .295                              | .46  | .29         | .32         | .495 | .32         | .60         | .92  | .61         |  |
| 21500        | .30                               | .47  | .295        | .325        | .505 | .325        | .62         | .94  | .63         |  |
| 22000        | .31                               | .485 | .305        | .34         | .515 | .335        | .635        | .965 | .64         |  |
| 22500        | .32                               | .50  | .31         | .345        | .52  | .34         | .65         | 1.00 | .65         |  |
| 23000        | .33                               | .515 | .32         | .35         | .535 | .345        | ...         | 1.03 | ...         |  |
| 23500        | .335                              | .53  | .33         | .36         | .555 | .35         | ...         | ...  | ...         |  |
| 24000        | .35                               | .54  | .34         | .37         | .57  | .36         | ...         | 1.07 | ...         |  |
| 24500        | .36                               | .555 | .35         | .38         | .58  | .37         | ...         | ...  | ...         |  |
| 25000        | .365                              | .565 | .355        | .385        | .585 | .375        | ...         | 1.14 | ...         |  |
| 25500        | .375                              | .585 | .365        | .39         | .60  | .385        | ...         | ...  | ...         |  |
| 26000        | .385                              | .60  | .38         | .40         | .61  | .395        | ...         | 1.16 | ...         |  |
| 26500        | .395                              | .615 | .385        | .415        | .625 | .405        | ...         | ...  | ...         |  |
| 27000        | ...                               | .625 | ...         | .42         | .645 | .41         | ...         | 1.25 | ...         |  |
| 27500        | ...                               | ...  | ...         | .43         | .66  | .42         | ...         | ...  | ...         |  |
| 28000        | ...                               | ...  | ...         | .445        | .675 | .43         | ...         | 1.33 | ...         |  |
| 28500        | ...                               | ...  | ...         | .45         | .69  | .445        | ...         | ...  | ...         |  |
| 29000        | ...                               | ...  | ...         | .46         | .71  | .455        | ...         | 1.41 | ...         |  |
| 29500        | ...                               | ...  | ...         | .465        | .725 | .46         | ...         | ...  | ...         |  |
| 30000        | ...                               | .69  | ...         | .475        | .74  | .47         | ...         | 1.49 | ...         |  |
| 31000        | ...                               | ...  | ...         | ...         | .78  | ...         | ...         | 1.55 | ...         |  |
| 32000        | ...                               | .76  | ...         | ...         | ...  | ...         | ...         | 1.60 | ...         |  |
| 34000        | ...                               | .85  | ...         | ...         | ...  | ...         | ...         | ...  | ...         |  |
| 36000        | ...                               | .94  | ...         | ...         | .92  | ...         | ...         | ...  | ...         |  |
| 37000        | ...                               | ...  | ...         | ...         | .98  | ...         | ...         | ...  | ...         |  |
| 37300        | ...                               | 1    | ...         | ...         | 1.00 | ...         | ...         | ...  | ...         |  |
| 38100        | ...                               | 1.18 | ...         | ...         | ...  | ...         | ...         | ...  | ...         |  |
| 40000        | ...                               | 1.25 | ...         | ...         | 1.20 | ...         | ...         | ...  | ...         |  |
| 41000        | ...                               | ...  | ...         | ...         | 1.30 | ...         | ...         | ...  | ...         |  |
| 44000        | ...                               | 1    | ...         | ...         | 1.50 | ...         | ...         | ...  | ...         |  |
| 45000        | ...                               | 1.85 | ...         | ...         | ...  | ...         | ...         | ...  | ...         |  |
| 46000        | ...                               | 1.97 | ...         | ...         | 1.70 | ...         | ...         | ...  | ...         |  |
| 47000        | ...                               | 2.15 | ...         | ...         | 1.95 | ...         | ...         | ...  | ...         |  |

Breaking weight of Beam XLVIII = 38,100 lbs.

" " " XLIX = 47,080 "

" " " L = 32,200 "

Table R shows deflections in inches of Canadian White Pine Beams which have been in service.

TABLE R.

Deflections of Beams LI to LIII.

| Loads in lbs. | LI.        |            |                |            | LII.       |            |            |                | LIII.      |            |            |            |                |            |            |  |
|---------------|------------|------------|----------------|------------|------------|------------|------------|----------------|------------|------------|------------|------------|----------------|------------|------------|--|
|               | 32<br>ins. | 64<br>ins. | Ends.<br>Ends. | 64<br>ins. | 32<br>ins. | 30<br>ins. | 60<br>ins. | Ends.<br>Ends. | 60<br>ins. | 30<br>ins. | 30<br>ins. | 60<br>ins. | Ends.<br>Ends. | 60<br>ins. | 30<br>ins. |  |
| 1000          | .02        | .02        | .035           | .02        | .02        | .02        | .01        | .025           | .01        | .02        | .03        | .01        | .04            | .02        | .03        |  |
| 1500          | .05        | .03        | .065           | .03        | .05        | .05        | .02        | .055           | .025       | .05        | .055       | .02        | .065           | .04        | .06        |  |
| 2000          | .06        | .05        | .09            | .05        | .07        | .060       | .040       | .075           | .040       | .070       | .08        | .04        | .10            | .05        | .085       |  |
| 2500          | .10        | .065       | .12            | .06        | .10        | .09        | .05        | .105           | .05        | .095       | .11        | .06        | .135           | .065       | .11        |  |
| 3000          | .11        | .08        | .145           | .07        | .12        | ...        | ...        | ...            | ...        | ...        | .135       | .08        | .16            | .08        | .14        |  |
| 3200          | ...        | ...        | ...            | ...        | ...        | .12        | .06        | .135           | .07        | .125       | ...        | ...        | ...            | ...        | ...        |  |
| 3500          | ...        | .09        | .175           | .085       | .15        | .14        | .07        | .155           | .08        | .145       | .16        | .095       | .20            | .09        | .16        |  |
| 4000          | ...        | .10        | .21            | .10        | .175       | .16        | .08        | .185           | .09        | .16        | .18        | .105       | .235           | .10        | .19        |  |
| 4500          | .19        | .12        | .24            | .115       | .20        | .18        | .10        | .21            | .11        | .18        | .21        | .11        | .26            | .12        | .22        |  |
| 5000          | .21        | .13        | .265           | .13        | .23        | .20        | .105       | .235           | .12        | .205       | .235       | .13        | .28            | .13        | .24        |  |
| 5500          | .25        | .14        | .30            | .145       | .25        | ...        | ...        | ...            | ...        | .26        | .145       | .325       | .15            | .27        | ...        |  |
| 5700          | ...        | ...        | ...            | ...        | ...        | .22        | .12        | .265           | .13        | .245       | ...        | ...        | ...            | ...        | ...        |  |
| 6000          | .27        | .15        | .325           | .16        | .275       | .245       | .13        | .285           | .14        | .25        | .29        | .16        | .35            | .165       | .30        |  |
| 6500          | .29        | .17        | .35            | .17        | .30        | .26        | .14        | .31            | .155       | .275       | .31        | .18        | .39            | .18        | .32        |  |
| 7000          | .31        | .185       | .385           | .185       | .33        | .29        | .15        | .345           | .175       | .30        | .34        | .19        | .42            | .19        | .35        |  |
| 7500          | .345       | .20        | .415           | .20        | .35        | ...        | ...        | ...            | ...        | .37        | .20        | .45        | .21            | .385       | ...        |  |
| 7800          | ...        | ...        | ...            | ...        | ...        | .31        | .16        | .375           | .19        | .325       | ...        | ...        | ...            | ...        | ...        |  |
| 8000          | .35        | .21        | .445           | .215       | .375       | .34        | .17        | .40            | .20        | .35        | .40        | .22        | .49            | .23        | .405       |  |
| 8500          | .38        | .225       | .47            | .235       | .40        | .35        | .185       | .415           | .215       | .36        | .425       | .24        | .515           | .24        | .44        |  |
| 9000          | .40        | .23        | .50            | .25        | .425       | .375       | .195       | .445           | .225       | .39        | .455       | .25        | .55            | .255       | .46        |  |
| 9500          | .425       | .25        | .53            | .26        | .45        | .40        | .21        | .475           | .24        | .41        | .47        | .27        | .585           | .27        | .495       |  |
| 10000         | .45        | .26        | .555           | .285       | .48        | .42        | .22        | .50            | .25        | .435       | .505       | .285       | .615           | .285       | .52        |  |
| 10500         | .47        | .27        | .585           | .29        | .50        | .45        | .24        | .535           | .27        | .46        | .53        | .29        | .65            | .30        | .55        |  |
| 11000         | .50        | .29        | .615           | .305       | .53        | ...        | ...        | ...            | ...        | .565       | .305       | .69        | .31            | .58        | ...        |  |
| 11500         | .515       | .30        | .63            | .315       | .55        | .47        | .25        | .56            | .28        | .485       | .59        | .32        | .725           | .33        | .60        |  |
| 12000         | .55        | .31        | .67            | .33        | .58        | ...        | ...        | ...            | ...        | ...        | .625       | .34        | .76            | .35        | .64        |  |
| 12500         | .57        | .33        | .70            | .35        | .60        | .51        | .27        | .615           | .31        | .53        | .65        | .353       | .795           | .365       | .665       |  |
| 13000         | .60        | .34        | .735           | .36        | .63        | .55        | .30        | .655           | .33        | .57        | .675       | .365       | .825           | .39        | .69        |  |
| 13500         | .62        | .35        | .76            | .37        | .66        | .57        | .31        | .685           | .345       | .59        | .71        | .385       | .855           | .405       | .72        |  |
| 14000         | .65        | .365       | .79            | .39        | .685       | .60        | .32        | .71            | .355       | .61        | .74        | .405       | .90            | .42        | .75        |  |
| 14500         | .67        | .38        | .82            | .40        | .71        | .615       | .34        | .74            | .37        | .64        | .77        | .42        | .94            | .43        | .79        |  |
| 15000         | .70        | .39        | .85            | .415       | .735       | .64        | .35        | .765           | .385       | .655       | .80        | .435       | .985           | .45        | .815       |  |
| 15500         | .725       | .41        | .875           | .435       | .76        | .66        | .36        | .79            | .39        | .68        | .835       | .46        | 1.02           | .47        | .85        |  |
| 16000         | .75        | .42        | .91            | .445       | .785       | .69        | .38        | .83            | .415       | .71        | .87        | .47        | 1.07           | .48        | .89        |  |
| 16500         | .77        | .435       | .94            | .455       | .81        | ...        | ...        | ...            | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 17000         | .80        | .45        | .97            | .47        | .84        | .72        | .395       | .865           | .43        | .74        | ...        | ...        | 1.15           | ...        | ...        |  |
| 17500         | .82        | .47        | 1.00           | .49        | .86        | .76        | .415       | .915           | .45        | .78        | ...        | ...        | ...            | ...        | ...        |  |
| 18000         | .85        | .475       | 1.03           | .51        | .89        | .79        | .44        | .95            | .47        | .81        | ...        | ...        | ...            | ...        | ...        |  |
| 18500         | .88        | .49        | 1.07           | .53        | .925       | ...        | ...        | ...            | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 19000         | .90        | .50        | 1.10           | .54        | .96        | ...        | ...        | ...            | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 19500         | .93        | .52        | 1.14           | .56        | .985       | ...        | ...        | ...            | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 20000         | .96        | .54        | 1.185          | .60        | 1.03       | ...        | ...        | 1.06           | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 20500         | 1.00       | ...        | 1.235          | ...        | 1.07       | ...        | ...        | ...            | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 21000         | 1.04       | ...        | 1.28           | ...        | 1.11       | ...        | ...        | 1.10           | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 21500         | ...        | ...        | 1.32           | ...        | ...        | ...        | ...        | ...            | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 22000         | ...        | ...        | ...            | ...        | ...        | ...        | ...        | 1.18           | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 22650         | ...        | ...        | 1.40           | ...        | ...        | ...        | ...        | ...            | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 23500         | ...        | ...        | ...            | ...        | ...        | ...        | ...        | 1.30           | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 24000         | ...        | ...        | ...            | ...        | ...        | ...        | ...        | 1.34           | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |
| 25000         | ...        | ...        | ...            | ...        | ...        | ...        | ...        | 1.46           | ...        | ...        | ...        | ...        | ...            | ...        | ...        |  |

Breaking weight of Beams LI = 22,730 lbs.

" " " LII = 26,320 "

" " " LIII = 18,600 "

Tables S and T shew deflections in inches of Canadian New Spruce Beams (B.C.).

TABLE S.

| Loads in<br>lbs. | Deflections of Beam LIV. |         |         |       |         |         |          |
|------------------|--------------------------|---------|---------|-------|---------|---------|----------|
|                  | 108 ins.                 | 72 ins. | 36 ins. | Ends. | 36 ins. | 72 ins. | 108 ins. |
| 1,000            | .14                      | .22     | .30     | .30   | .26     | .20     | .11      |
| 1,500            | .15                      | .24     | .33     | .34   | .30     | .23     | .12      |
| 2,000            | .17                      | .28     | .37     | .38   | .34     | .25     | .15      |
| 2,500            | .18                      | .31     | .41     | .43   | .38     | .28     | .16      |
| 3,000            | .19                      | .34     | .44     | .46   | .42     | .31     | .18      |
| 3,500            | .21                      | .36     | .48     | .51   | .45     | .34     | .19      |
| 4,000            | .22                      | .39     | .52     | .56   | .50     | .37     | .21      |
| 4,500            | .24                      | .42     | .56     | .60   | .54     | .39     | .22      |
| 5,000            | .25                      | .45     | .60     | .64   | .57     | .42     | .24      |
| 5,500            | .26                      | .47     | .63     | .68   | .60     | .45     | .25      |
| 6,000            | .27                      | .50     | .67     | .72   | .64     | .48     | .26      |
| 6,500            | .29                      | .53     | .71     | .76   | .67     | .50     | .28      |
| 7,000            | .31                      | .56     | .75     | .80   | .71     | .52     | .30      |
| 7,500            | .32                      | .59     | .79     | .84   | .75     | .56     | .31      |
| 8,000            | .34                      | .61     | .82     | .88   | .79     | .60     | .32      |
| 8,500            | .35                      | .65     | .86     | .92   | .83     | .61     | .34      |
| 9,000            | .37                      | .67     | .90     | .97   | .86     | .65     | .35      |
| 9,500            | .38                      | .70     | .94     | 1.01  | .90     | .67     | .36      |
| 10,000           | .40                      | .73     | .97     | 1.05  | .94     | ...     | .39      |
| 10,500           | .41                      | .76     | 1.01    | 1.09  | .98     | .71     | .40      |
| 11,000           | .43                      | .79     | 1.05    | 1.14  | 1.02    | .72     | .41      |
| 11,500           | .44                      | .84     | 1.09    | 1.17  | 1.05    | .75     | .43      |
| 12,000           | .46                      | .84     | 1.13    | 1.21  | 1.09    | .78     | .45      |
| 12,500           | .48                      | .87     | 1.16    | 1.26  | 1.14    | .82     | .46      |
| 13,000           | .49                      | .89     | 1.19    | 1.29  | 1.16    | .83     | .48      |
| 13,500           | .50                      | .92     | 1.23    | 1.31  | 1.20    | .84     | .49      |
| 14,000           | .51                      | .95     | 1.27    | 1.38  | 1.24    | ...     | .50      |
| 14,500           | .53                      | .98     | 1.30    | 1.42  | 1.28    | ...     | .51      |
| 15,000           | .54                      | .99     | 1.32    | 1.45  | 1.31    | ...     | .53      |
| 15,500           | .55                      | 1.00    | 1.32    | 1.46  | 1.32    | .99     | .54      |
| 16,000           | .55                      | 1.00    | 1.33    | 1.48  | 1.34    | 1.01    | .54      |
| 16,500           | .55                      | 1.01    | 1.34    | 1.50  | 1.35    | 1.02    | .55      |
| 17,000           | .56                      | 1.01    | 1.34    | 1.51  | 1.36    | 1.03    | .56      |
| 17,500           | .56                      | 1.02    | 1.35    | 1.52  | 1.40    | 1.05    | .57      |
| 18,000           | .56                      | 1.03    | 1.35    | 1.54  | 1.41    | 1.06    | .58      |
| 18,500           | .57                      | 1.03    | 1.36    | 1.55  | 1.43    | 1.07    | .59      |
| 19,000           | .57                      | 1.04    | 1.36    | 1.57  | 1.45    | 1.09    | .60      |
| 19,500           | .58                      | 1.04    | 1.36    | 1.58  | 1.46    | 1.11    | .60      |
| 20,000           | .58                      | 1.05    | 1.37    | 1.60  | 1.47    | 1.12    | .61      |
| 20,500           | .71                      | 1.32    | 1.52    | 1.93  | 1.74    | 1.30    | .70      |
| 21,000           | .72                      | 1.35    | 1.80    | 1.98  | 1.78    | 1.33    | .71      |
| 21,500           | .74                      | 1.38    | 1.85    | 2.02  | 1.82    | 1.36    | .73      |
| 22,000           | .76                      | 1.41    | 1.90    | 2.07  | 1.86    | 1.38    | .75      |
| 23,400           | ...                      | ...     | ...     | 2.20  | ...     | ...     | ...      |
| 26,200           | ...                      | ...     | ...     | 2.50  | ...     | ...     | ...      |
| 27,800           | ...                      | ...     | ...     | 2.75  | ...     | ...     | ...      |
| 29,000           | ...                      | ...     | ...     | 2.85  | ...     | ...     | ...      |
| 29,900           | ...                      | ...     | ...     | 3.00  | ...     | ...     | ...      |
| 30,800           | ...                      | ...     | ...     | 3.15  | ...     | ...     | ...      |
| 32,000           | ...                      | ...     | ...     | 3.25  | ...     | ...     | ...      |
| 32,500           | ...                      | ...     | ...     | 3.35  | ...     | ...     | ...      |
| 33,200           | ...                      | ...     | ...     | 3.70  | ...     | ...     | ...      |
| 33,500           | ...                      | ...     | ...     | 3.80  | ...     | ...     | ...      |
| 33,800           | ...                      | ...     | ...     | 4.00  | ...     | ...     | ...      |
| 34,400           | ...                      | ...     | ...     | 4.10  | ...     | ...     | ...      |
| 34,800           | ...                      | ...     | ...     | 4.25  | ...     | ...     | ...      |
| 35,600           | ...                      | ...     | ...     | 4.50  | ...     | ...     | ...      |
| 36,200           | ...                      | ...     | ...     | 4.60  | ...     | ...     | ...      |
| 36,300           | ...                      | ...     | ...     | 4.75  | ...     | ...     | ...      |
| 36,600           | ...                      | ...     | ...     | 4.90  | ...     | ...     | ...      |
| 36,800           | ...                      | ...     | ...     | 5.00  | ...     | ...     | ...      |
| 38,250           | ...                      | ...     | ...     | 5.50  | ...     | ...     | ...      |

Breaking weight of Beam LIV = 36,800 lbs.

TABLE T.

## Deflections of Beams LV and LVI.

| Loads in<br>lbs. | LV.     |      |         | LVI.    |      |         |
|------------------|---------|------|---------|---------|------|---------|
|                  | 30 ins. | End. | 30 ins. | 30 ins. | End. | 30 ins. |
| 10,000           | .05     | .09  | .05     | .1      | .07  | .0      |
| 11,000           | .06     | .10  | .06     | .11     | .09  | .06     |
| 12,000           | .07     | .10  | .065    | .12     | .10  | .06     |
| 13,000           | .07     | .11  | .07     | .13     | .10  | .07     |
| 14,000           | .08     | .11  | .075    | .13     | .11  | .08     |
| 15,000           | .08     | .12  | .08     | .135    | .12  | .09     |
| 16,000           | .09     | .13  | .085    | .14     | .13  | .09     |
| 17,000           | .10     | .14  | .09     | .145    | .14  | .095    |
| 18,000           | .10     | .15  | .095    | .15     | .15  | .10     |
| 19,000           | .11     | .16  | .105    | .16     | .15  | .105    |
| 20,000           | .11     | .17  | .11     | .16     | .16  | .11     |
| 21,000           | .12     | .17  | .12     | .17     | .17  | .115    |
| 22,000           | .12     | .18  | .125    | .175    | .18  | .12     |
| 23,000           | .13     | .19  | .13     | .185    | .19  | .12     |
| 24,000           | .13     | .20  | .135    | .19     | .19  | .13     |
| 25,000           | .14     | .21  | .14     | .195    | .20  | .14     |
| 26,000           | .15     | .22  | .145    | .2      | .20  | .15     |
| 27,000           | .15     | .23  | .15     | .2      | .22  | .15     |
| 28,000           | .16     | .24  | .16     | .215    | .24  | .16     |
| 29,000           | .16     | .25  | .165    | .22     | .24  | .16     |
| 30,000           | .17     | .26  | .17     | .225    | .25  | .17     |
| 31,000           | .17     | .27  | .18     | .23     | .26  | .17     |
| 32,000           | .18     | .28  | .185    | .235    | .27  | .18     |
| 33,000           | .19     | .29  | .19     | .24     | .28  | .185    |
| 34,000           | .20     | .30  | .20     | .245    | .29  | .19     |
| 35,000           | .20     | .31  | .205    | .255    | .29  | .20     |
| 36,000           | .21     | .32  | .21     | .267    | .31  | .20     |
| 37,000           | .21     | .33  | .215    | .27     | .32  | .21     |
| 38,000           | .22     | .34  | .225    | .28     | .33  | .215    |
| 39,000           | .22     | .35  | .23     | .28     | .34  | .225    |
| 40,000           | .23     | .36  | .24     | .285    | .35  | .235    |
| 41,000           | .24     | .37  | .25     | .29     | .36  | .24     |
| 42,000           | .25     | .38  | .255    | .30     | .37  | .25     |
| 43,000           | .25     | .39  | .26     | .31     | .39  | .255    |
| 44,000           | .26     | .40  | .27     | .32     | .40  | .26     |
| 45,000           | .27     | .41  | .28     | .325    | .41  | .27     |
| 46,000           | .27     | .42  | .29     | .335    | .42  | .28     |
| 47,000           | .28     | .44  | .30     | .34     | .45  | .285    |
| 48,000           | .29     | .45  | .305    | .35     | .46  | .30     |
| 49,000           | .30     | .46  | .315    | .36     | .47  | .305    |
| 50,000           | .31     | .48  | .32     | .37     | .49  | .315    |
| 51,000           | .31     | .50  | .33     | .38     | .50  | .325    |
| 52,000           | ....    | .... | ....    | .39     | .52  | .34     |
| 53,000           | ....    | .... | ....    | .40     | .55  | .35     |
| 54,000           | ....    | .... | ....    | .41     | .56  | .36     |
| 55,000           | ....    | .... | ....    | .42     | .59  | .37     |
| 56,000           | ....    | .... | ....    | .44     | .60  | .39     |

Breaking weight of Beam LV = 73,000 lbs.

" " " LVI = 70,000 "

Table U and T show deflections of Canadian Spruce Beams which have been in service.

TABLE U.

| Loads in<br>lbs. | Deflections of Beams LVII to LIX. |       |         |         |       |         |         |  |
|------------------|-----------------------------------|-------|---------|---------|-------|---------|---------|--|
|                  | LVII.                             |       |         | LVIII.  |       |         | LIX.    |  |
|                  | 45 ins.                           | Ends. | 45 ins. | 45 ins. | Ends. | 45 ins. | At End. |  |
| 1,000            | .01                               | .02   | .01     | .030    | .040  | .040    | .....   |  |
| 1,500            | .02                               | .05   | .025    | .050    | .065  | .056    | .....   |  |
| 2,000            | .035                              | .07   | .05     | .060    | .100  | .070    | .09     |  |
| 2,500            | .05                               | .09   | .07     | .080    | .130  | .095    | .....   |  |
| 3,000            | .06                               | .11   | .09     | .100    | .160  | .115    | .....   |  |
| 3,500            | .075                              | .14   | .10     | .120    | .190  | .130    | .....   |  |
| 4,000            | .09                               | .15   | .115    | .140    | .215  | .150    | .20     |  |
| 4,500            | .10                               | .17   | .135    | .160    | .250  | .170    | .....   |  |
| 5,000            | .115                              | .20   | .15     | .175    | .270  | .190    | .25     |  |
| 5,500            | .13                               | .22   | .165    | .200    | .300  | .205    | .....   |  |
| 6,000            | .14                               | .24   | .19     | .210    | .330  | .225    | .30     |  |
| 6,500            | .16                               | .26   | .20     | .240    | .360  | .248    | .....   |  |
| 7,000            | .17                               | .28   | .21     | .255    | .390  | .251    | .36     |  |
| 7,500            | .185                              | .30   | .22     | .275    | .420  | .285    | .....   |  |
| 8,000            | .20                               | .33   | .235    | .300    | .450  | .305    | .41     |  |
| 8,500            | .21                               | .35   | .25     | .315    | .475  | .320    | .....   |  |
| 9,000            | .225                              | .37   | .26     | .340    | .500  | .342    | .....   |  |
| 9,500            | .235                              | .39   | .275    | .350    | .535  | .362    | .....   |  |
| 10,000           | .25                               | .41   | .29     | .375    | .570  | .380    | .52     |  |
| 10,500           | .265                              | .44   | .30     | .400    | .590  | .400    | .....   |  |
| 11,000           | .275                              | .46   | .315    | .410    | .620  | .415    | .....   |  |
| 11,500           | .29                               | .47   | .33     | .440    | .650  | .440    | .....   |  |
| 12,000           | .30                               | .50   | .35     | .450    | .675  | .460    | .....   |  |
| 12,500           | .32                               | .52   | .36     | .475    | .705  | .480    | .....   |  |
| 13,000           | .335                              | .54   | .37     | .500    | .745  | .500    | .....   |  |
| 13,500           | .35                               | .55   | .39     | .510    | .765  | .515    | .....   |  |
| 14,000           | .36                               | .57   | .40     | .540    | .800  | .540    | .....   |  |
| 14,500           | .37                               | .60   | .415    | .550    | .840  | .555    | .....   |  |
| 15,000           | .39                               | .62   | .43     | .575    | .860  | .580    | .....   |  |
| 15,500           | .40                               | .65   | .45     | .600    | .900  | .620    | .....   |  |
| 16,000           | .415                              | .67   | .46     | .615    | .920  | .630    | .....   |  |
| 16,500           | .435                              | .69   | .47     | .640    | .960  | .645    | .....   |  |
| 17,000           | .45                               | .72   | .49     | .655    | .990  | .665    | .....   |  |
| 17,500           | .46                               | .74   | .50     | .....   | 1.025 | .....   | .....   |  |
| 18,000           | .475                              | .76   | .52     | .....   | ..... | .....   | .....   |  |
| 18,500           | .50                               | .78   | .54     | .....   | ..... | .....   | .....   |  |
| 19,000           | .51                               | .80   | .56     | .....   | 1.120 | .....   | .....   |  |
| 19,500           | .525                              | .83   | .575    | .....   | ..... | .....   | .....   |  |
| 20,000           | .55                               | .87   | .59     | .....   | 1.180 | .....   | .....   |  |
| 21,000           | .....                             | .92   | .....   | .....   | 1.270 | .....   | .....   |  |
| 22,000           | .....                             | .97   | .....   | .....   | 1.350 | .....   | .....   |  |
| 23,000           | .....                             | 1.10  | .....   | .....   | 1.430 | .....   | .....   |  |
| 24,000           | .....                             | 1.50  | .....   | .....   | 1.570 | .....   | .....   |  |
| 25,000           | .....                             | 2.40  | .....   | .....   | 1.850 | .....   | .....   |  |
| 26,000           | .....                             | ..... | .....   | .....   | 2.040 | .....   | .....   |  |
| 27,000           | .....                             | ..... | .....   | .....   | ..... | .....   | .....   |  |

The Breaking weight of Beam LVII = 25,700 lbs.

" " " LVIII = 27,470 "

" " " LIX = 21,700 "

TABLE V.

| Loads in<br>lbs. | Deflections of Beams LX to LXI. |         |         |         |         |         |
|------------------|---------------------------------|---------|---------|---------|---------|---------|
|                  | LX.                             |         |         | LXI.    |         |         |
|                  | 34 ins.                         | At End. | 34 ins. | 46 ins. | At End. | 46 ins. |
| 500              | .....                           | .....   | .....   | .015    | .02     | .01     |
| 1,000            | .005                            | .015    | .005    | .04     | .05     | .03     |
| 1,500            | .005                            | .045    | .015    | .06     | .09     | .05     |
| 2,000            | .020                            | .050    | .020    | .085    | .14     | .07     |
| 2,500            | .035                            | .070    | .035    | .105    | .17     | .10     |
| 3,000            | .045                            | .080    | .045    | .135    | .20     | .12     |
| 3,500            | .055                            | .100    | .055    | .150    | .24     | .15     |
| 4,000            | .065                            | .120    | .065    | .180    | .290    | .170    |
| 4,500            | .070                            | .140    | .070    | .20     | .320    | .190    |
| 5,000            | .080                            | .145    | .080    | .23     | .350    | .210    |
| 5,500            | .095                            | .165    | .100    | .245    | .390    | .245    |
| 6,000            | .105                            | .185    | .105    | .265    | .430    | .260    |
| 6,500            | .115                            | .200    | .115    | .29     | .46     | .28     |
| 7,000            | .130                            | .220    | .130    | .31     | .51     | .31     |
| 7,500            | .140                            | .240    | .145    | .34     | .54     | .335    |
| 8,000            | .155                            | .255    | .155    | .36     | .57     | .355    |
| 8,500            | .175                            | .285    | .170    | .39     | .61     | .38     |
| 9,000            | .180                            | .300    | .185    | .41     | .65     | .40     |
| 9,500            | .190                            | .320    | .195    | .435    | .70     | .43     |
| 10,000           | .205                            | .345    | .205    | .455    | .74     | .45     |
| 10,500           | .220                            | .365    | .220    | .49     | .76     | .485    |
| 11,000           | .230                            | .380    | .230    | .51     | .79     | .50     |
| 11,500           | .250                            | .415    | .255    | .54     | .85     | .54     |
| 12,000           | .....                           | .440    | .....   | .....   | .92     | .....   |
| 13,000           | .....                           | .457    | .....   | .....   | .95     | .....   |
| 14,000           | .....                           | .510    | .....   | .....   | 1.03    | .....   |
| 15,000           | .....                           | .565    | .....   | .....   | 1.08    | .....   |
| 16,000           | .....                           | .610    | .....   | .....   | 1.20    | .....   |
| 17,000           | .....                           | .690    | .....   | .....   | 1.32    | .....   |
| 18,000           | .....                           | .750    | .....   | .....   | 1.41    | .....   |
| 19,000           | .....                           | .870    | .....   | .....   | .....   | .....   |
| 20,500           | .....                           | .000    | .....   | .....   | .....   | .....   |

Breaking weight of Beam LX = 16,050 lbs.

" " " LXI = 18,400 "

## COMPRESSIVE STRENGTH.

The experiments to determine the compressive strength of the various timbers have been chiefly made with columns cut out of the sticks already tested transversely. These columns were, in the first place, carefully examined to see that they had suffered no injury. The following inferences may be drawn :—

(1) The compressive strength of Douglas Fir and of other soft timbers is much less near the heart than at a distance from the heart. Attention may be directed to the case of three equal specimens A, B and C (see photograph page 19), cut out of Beam XIII. The compressive strength of C was found to be 7,706 lbs. per square inch as compared with 6,653 lbs. per square inch, the compressive strength of A. The difference of strength is undoubtedly due to the very much larger proportion of soft to hard fibre, or of summer to spring growth in C, as compared with the proportion in the case of A. The compressive strength of the timber increases with the density of the annular rings.

(2) When knots are present in a timber column, the column will almost invariably fail at a knot or in consequence of the proximity of a knot.

(3) Any imperfection, as, for example, a small hole made by an ordinary cant hook, tends to introduce incipient bending, or crippling.

(4) When the failures of average specimens commence by an initial bending, the compressive strengths of columns of about 10 to 25 diameters in length agree very well with the results obtained by Gordon's formula, the coefficients of direct compressive strength per square inch being 6000 lbs. for Douglas Fir and 5000 lbs. for White Pine.

Gordon's formula, however, is not at all applicable in the case of specially good or bad specimens. It is often found that a very clear, sound specimen, of even more than 20 diameters in length, will show no signs of bending, but will suddenly fail by crippling under a load as great as that sufficient to crush a shorter specimen.

(5) The greatest care should be observed in avoiding obliqueness of grain in columns, as the *effective* bearing area, and therefore also the strength, are considerably diminished.

(6) If the end bearings are not perfectly flat and parallel, the columns will in all probability fail by bending oneave to the longest side.

(7) The *average* strength per square inch, independent of the ratio of length to diameter, is :

|      |                          |
|------|--------------------------|
| 5974 | lbs. for New Douglas Fir |
| 6265 | " for Old " "            |
| 4067 | " for New Red Pine       |
| 3843 | " for New White Pine     |
| 2772 | " for Old " "            |
| 3617 | " for New Spruce (B.C.)  |
| 5136 | " Old Spruce             |

It should be pointed out that none of the old Douglas Fir columns exceeded 4.4 diameters in length, while the great majority of the new Douglas Fir columns were from 4 to 25 diameters in length. This explains the reason of the greater average compressive strength of the old Douglas Fir. A similar remark applies to the New and Old Spruce.

Table giving in detail the results of the experiments on the different specimens :—

#### RESULTS OF COMPRESSION TESTS ON NEW DOUGLAS FIR.

| Dimensions in ins.<br>Lengths. | Breaking<br>Load in lbs.<br>per sq. in. | Weight in lbs.<br>per cu. ft. | Remarks.   |
|--------------------------------|---|-------------------------------|--|
| 3.07 × 3.08 × 3.11             | 6367                                    |                               | Failed by bulging.   |
| 3.06 × 3.08 × 3.10             | 5760                                    |                               | Failed by folding.   |
| 2.63 × 3.63 × 5.81             | 4923                                    | 30.3                          | Specimen 3" or 4" from heart; grain straight; one small knot on high edge. Failed by crippling at knot on high edge.                           |
| 3.65 × 3.65 × 6.12             | 3678                                    | 29.8                          | Heart piece; grain straight but seasoned; annular rings very wide; two knots, one on high edge. Failed at this latter by crippling.            |
| 2.19 × 3.74 × 5.40             | 4761                                    | 38.4                          | Straight grained; one large knot from side to side; specimen 3" or 4" away from centre. Failed at knot.  |
| 4.10 × 4.30 × 8.05             | 5218                                    | 32.9                          | Large knot on one end; many small knots all through piece; also heavy season cracks. Failed by bursting along season cracks and through knots. |
| 2.15 × 2.25 × 9.2              | 5809                                    | 38.8                          | All clear. Failed by crippling.  |
| 2.17 × 2.25 × 9.14             | 7313                                    | 35.1                          | Sound, clear and straight grained; small deficiency on one side at end. Failed by crippling.   |
| 2.12 × 2.16 × 9.15             | 7294                                    | 38.7                          | Straight grained; clear on three sides; 4th side old, with bad defect 4 ins. from one end. Bulged and failed at defect.                        |
| 2.22 × 2.22 × 9.07             | 8177                                    | 37.5                          | Straight grained and clear; one bad season crack. Failed by crippling.   |
| 2.13 × 2.20 × 9.15             | 6850                                    | 36.5                          | Straight grained; small knot near one corner 3 ins. from end. Failed at this knot.   |

RESULTS OF COMPRESSION TESTS ON NEW DOUGLAS FIR.—*Continued.*

|                     |      |      |  |
|---------------------|------|------|--|
| 3.32 × 3.32 × 9.62  | 3810 | 29.5 | Heart piece; straight grained; two heavy season cracks; three or four pin knots. Failed by bulging on season cracks; and crippling through two pin knots on same side.   |
| 3.33 × 3.34 × 10.58 | 4388 | 33.0 | Clear; straight grained. Failed on high side. Specimen 3" or 4" from heart.  |
| 3.45 × 3.50 × 10.60 | 7000 | 32.6 | Clear and straight grain; somewhat shaken; crippled 6 ins. from end.   |
| 2.74 × 4.27 × 11.25 | 6837 | 35.3 | Clear and straight grained; some season cracks; failed by crippling directly across about 1½ ins. from one end.  |
| 2.85 × 4.25 × 11.27 | 5615 | 30.0 | Clear and straight grained, but season cracks along annular rings, and one heavy season crack along medullary rays. Failed first by bursting apart of piece at a season crack, then by crippling of the remainder. |
| 3.94 × 3.95 × 11.97 | 7069 | 33.8 | Clear straight grain; season crack on one side. Failed by crippling at middle on the highest edge.   |
| 2.72 × 2.92 × 11.85 | 8942 | 40.0 | Clear and straight grain; shaken over 8 ins. crippled 4 ins. from end.   |
| 3.46 × 3.48 × 12.04 | 5481 | 30.4 | Two sets of knots, one at one end, the other at centre. Failed at both by crippling, at same time.   |
| 4.05 × 4.10 × 12.01 | 5542 | 35.1 | Knots (heavy) on one end; also several near other end; grain curved at various places due to knots. Grain bent at knot at end.   |
| 2.85 × 3.75 × 12.5  | 6155 | 38.3 | All clear. Failed by crippling.  |
| 2.92 × 3.79 × 12.5  | 5966 | 39.3 | All clear. Failed by crippling.  |
| 2.9 × 4.37 × 12.0   | 6265 | 35.5 | One old side; grain straight and parallel. One side inclined 1-in. in 12 ins.; on other side, two season cracks. Failed by crippling.  |
| 2.79 × 3.43 × 12.0  | 5363 | 35.7 | One old side; grain straight and nearly parallel; no seasoning cracks. Failed by crippling.  |
| 2.92 × 4.42 × 12.0  | 5262 | 34.2 | One old side, grain straight and parallel; one season crack. Failed by crippling.  |
| 2.87 × 3.39 × 12.0  | 6784 | 35.1 | Two old sides; grain nearly parallel; no season cracks. Failed by crippling.   |
| 2.93 × 3.42 × 12.03 | 5520 | 33.9 | Clear and straight grained; one old side with deep seasoning cracks; a slight crack through centre of piece. Crippled 4 ins. from end, and bulged along season crack.  |
| 2.80 × 4.40 × 12.0  | 5060 | 36.4 | Straight grained; one old side with many season cracks. Failed by splitting down season cracks and afterwards crippling.   |

RESULTS OF COMPRESSION TESTS ON NEW DOUGLAS FIR.—*Continued.*

|                       |      |      |  |
|-----------------------|------|------|--|
| 2.78 × 4.38 × 12.0    | 6500 | 35.5 | Straight grained and clear; one old side with season crack nearly across piece. Crippled 3 ins. from one end.  |
| 2.82 × 3.48 × 12.02   | 6010 | 35.9 | Grain straight; two old sides; piece sound, no flaws. Crippled near one end.   |
| 3.3 × 3.98 × 12.0     | 5560 | 34.2 | Grain straight and clear, except small pin knot on a corner 4 ins. from end; had two bad season cracks the whole length. Crippled 4 ins. from end induced by season cracks; also bulged out. |
| 3.38 × 3.43 × 13.53   | 6816 | 34.7 | Clear; grain bent out of straight at one end, due to proximity of knot, also somewhat shaken. Failed by bursting along fibres out of parallel.   |
| 2.20 × 2.24 × 13.78   | 5638 | 34.3 | Grain out of parallel for 1 in. in length; knot on one corner of end. Burst along shaken fibres out of parallel.   |
| 3.38 × 3.45 × 13.90   | 6861 | 33.8 | Straight grained, except one-half of a knot on one end. Failed by crippling near knot at end.  |
| 4.03 in diar. × 48.01 | 5856 | 31.3 | Grain parallel, no knots; two small cracks and a small split; annular rings nearly straight. Failed by bending concave to a high corner.   |
| 2.84 × 4.23 × 13.12   | 5828 | 31.5 | Straight grained, small pin knot 3 ins. from one end; season cracks from end to end through middle, passing through knot. Failure by opening of season cracks, and crippling through knot.   |
| 4.10 × 4.45 × 14.47   | 7188 | 39.1 | Clear; grain out of parallel. Failed by crippling and shearing in of unsupported fibres.   |
| 2.70 × 2.90 × 15.96   | 8365 | 39.5 | Clear, straight grain shaken over a length of 11 ins. Crippled 5 ins. from end.  |
| 2.16 × 2.20 × 16.29   | 6442 | 36.0 | Clear, not straight grain; somewhat shaken; sheared along shake in grain which being cut off parallel had no bottom support.   |
| 4.08 in diar. × 24.12 | 6595 | 31.8 | Clear and straight grained. Failed by crippling 10 ins. from end.  |
| 2.70 × 4.20 × 16.45   | 6349 | 30.8 | Straight grained; season cracks on one side; several small pin knots. Failed by crippling 2 ins. from one end through one of the pin knots.  |
| 2.38 × 3.56 × 16.74   | 7143 | 33.0 | Straight grain; some small pin knots. Crippled through the largest one at centre.  |
| 1.73 × 5.98 × 17.73   | 4209 | 38.7 | Grain parallel knot on edge 4 ins. from end; also bad season crack and small deficiency in one corner for 6 ins. from one end. Burst at knot and split along season crack.                   |

RESULTS OF COMPRESSION TESTS ON NEW DOUGLAS FIR.—*Continued.*

|                     |      |      |  |
|---------------------|------|------|--|
| 17 × 2.25 × 17.12   | 7700 | 35.6 | Clear, straightgrained Failed by bending and crippling 3 ins. from end.  |
| 3.11 × 4.00 × 17.49 | 4702 | 33.2 | Two heavy knots at centre, one running from side to side through centre; grain crooked and not parallel. Failed by grain shearing and bursting through knot at centre. |
| 3.12 × 4.03 × 17.70 | 4217 | 34.2 | One heavy knot at centre running from corner to corner, other smaller knots; grain crooked and out of parallel. Crippled at knot at centre.                            |
| 1.75 × 5.82 × 17.79 | 5135 | 37.8 | Grain straight and sound; season cracks in centre. Failed by crippling at both ends and also by bending, which probably first caused failure.                          |
| 3.95 × 5.81 × 17.80 | 6432 | 39.1 | Grain clear and straight, but not parallel; slight season cracks. Failed by cripple across 4 ins. from one end.  |
| 3.95 × 5.92 × 17.82 | 5359 | 38.0 | Grain clear and straight; some season cracks. Crippled 6 ins. from end.  |
| 4.97 × 4.95 × 17.83 | 4504 | 37.9 | Grain straight and parallel; bad knot 7 ins. from end passing through piece. Failed by bursting at knot and along grain.   |
| 1.71 × 5.95 × 17.84 | 5464 | 36.0 | Grain parallel and clear; bad season crack through heart. Failed by bending at centre. Crippled on concave side.   |
| 1.79 × 6.00 × 17.85 | 6034 | 36.3 | Grain straight and clear; bad season cracks; also chip out on a corner 4 ins. from one end. Failed at sound end by crippling and by opening of season crack.           |
| 3.95 × 5.95 × 17.89 | 6225 | 38.9 | Clear and straight grained; slight season checks. Crippled 3 ins. from one end.  |
| 4.08 × 4.45 × 19.68 | 6437 | 36.7 | Clear, but badly out of parallel. Failed by bursting along fibres out of parallel.   |
| 3.02 × 4.04 × 19.97 | 3240 | 30.8 | Two heavy knots at centre, one also at one end, several others smaller ones. Failed by bursting down centre through knots.   |
| 3.85 × 3.91 × 24.05 | 5382 | 35.2 | Grain straight; two knots on adjacent sides, one at 8 ins. from each end; season cracks running diagonally at one end. Failed by crippling at large knot.              |
| 4.35 × 4.85 × 29.75 | 3630 | 28.0 | Failed by shearing and crippling; grain clear, but not quite parallel.   |
| 2.20 × 2.24 × 21.05 | 7424 | 35.0 | Clear, and straight grained; tested before as pillar. Failed by bending 4 ins. from end.   |
| 2.92 × 3.30 × 24.27 | 4606 | 34.6 | Straight grain; knot 6 ins. from end passing through a corner. Crippled at knot.   |

RESULTS OF COMPRESSION TESTS ON NEW DOUGLAS FIR.—*Continued.*

|                     |      |       |  |
|---------------------|------|-------|--|
| 2.60 × 3.23 × 25.4  | 4416 | 34.7  | Straight grain; large knot 4 ins. from end on an edge. Failed by crippling at knot.  |
| 2.27 × 2.28 × 23.46 | 4363 | 36.91 | Straight grained; clear except part of knot on one end. Failed by crippling at knot.   |
| 4.20 × 4.36 × 27.88 | 2622 | 32.4  | Heart; grain 2½ ins. out of straight; heavy season cracks; two large knots. Failed by bulging along season crack and at knots 14 ins. from end.  |
| 4.05 × 4.20 × 24.70 | 5026 | 33.9  | Tested before as pillar, failed then at 67,200 lbs. This portion had straight grain; two knots close together 8 ins. from one end going through piece. Failed by crippling at these knots. |
| 2.61 × 2.65 × 24.42 | 6237 | 36.0  | Straight grain; season crack across end running half the length of the piece; knot 3 ins. from other end ½ in. in diameter. Crippled at the knot.  |
| 2.65 × 2.66 × 26.24 | 6865 | 36.4  | Straight grained and clear; season crack running down about 8 ins. Crippled clean across at foot of season crack, apparently not induced by seasoning.                                     |
| 2.00 × 2.01 × 27.40 | 6841 | 34.5  | Clear and straight grain; heavy season crack. Burst from end to end on season crack.   |
| 2.88 × 2.95 × 23.91 | 8106 | 38.8  | Clear, straight grained. Crippled 8 ins. from one end.   |
| 2.87 × 2.93 × 25.00 | 6600 | 35.5  | Clear, nearly straight grained; slight season crack. Failed by a bulging on season crack and afterwards crippled on reduced section at centre.   |
| 2.88 × 2.90 × 24.40 | 7856 | 36.4  | Clear, straight grained. Failed by direct cripplg.   |
| 2.87 × 2.90 × 24.55 | 8065 | 38.0  | Clear and straight grained. Failed by direct crippling 8 ins. from end.  |
| 2.90 × 2.95 × 25.70 | 8023 | 36.3  | Clear and straight grained. Failed by direct crippling 15 ins. from end.   |
| 2.78 × 2.87 × 25.95 | 9700 | 40.9  | Deficiency near centre, about ½ in. by 1 in. (resin); fibre crooked through vicinity of knot; otherwise clear and straight grained. Failed at crooked fibres at deficiency.                |
| 2.89 × 2.90 × 26.69 | 8269 | 33.4  | Clear and straight grained; failed by compression of fibres on a corner.   |
| 2.82 × 2.97 × 25.15 | 9104 | 40.2  | Very heavy summer rings; clear; fibres bent 12 ins. from one end at one side due to vicinity of a knot. Failed at crooked fibres.  |
| 4.77 × 5.82 × 26.15 | 7709 | 36.5  | Did not fail.  |
| 4.77 × 4.68 × 22.32 | 8411 |       | Same as preceding with piece cut off; clear and straight grain.  |

RESULTS OF COMPRESSION TESTS ON NEW DOUGLAS FIR.—*Continued.*

|                     |      |      |   |
|---------------------|------|------|---|
| 4.70 × 5.85 × 25.78 | 6653 | 29.2 | Straight grained; one knot from side to side at centre. Failed by crippling and bulging at knot.  |
| 2.27 × 2.27 × 31.0  | 3823 | 37.2 | Grain not straight; one pin knot; also knot on one edge 12 ins. from end. Failed by bending at knot on high corner.   |
| 3.38 × 4.33 × 32.20 | 6425 | 41.3 | Clear, straight grained. Crippled 1 ft. from end.   |
| 3.39 × 4.42 × 30.90 | 5935 | 37.8 | Clear, straight grained; external fibre burst; then crippled near centre.   |
| 3.38 × 4.42 × 32.32 | 6111 | 43.3 | Clear, straight grained; burst, then crippled at centre.  |
| 3.37 × 4.38 × 32.5  | 5420 | 38.9 | Clear, straight grained; season crack on one side; small season crack across end. Crippled near end.  |
| 3.35 × 4.36 × 31.55 | 6486 | 43.1 | Clear and straight grained. Crippled near end.  |
| 3.41 × 4.45 × 32.4  | 5880 | 37.6 | Clear and straight grained. Crippled near end.  |
| 3.27 × 3.42 × 31.75 | 5760 | 33.5 | Straight grained; knot $\frac{1}{2}$ in. diar., from side to side. Failed by crippling at this knot 8 ins. from one end.  |
| 2.65 × 2.86 × 30.65 | 8047 | 36.3 | Clear, straight grained. Failed by crippling 8 ins. from one end.   |
| 2.67 × 2.88 × 31.83 | 7607 | 35.3 | Clear straight grained. Failed by crippling and bending at same instant at centre.  |
| 3.28 × 3.45 × 33.81 | 6940 | 35.7 | Clear, and straight grained. Failed by bending 10 ins. from one end.  |
| 2.75 × 2.82 × 30.47 | 5480 | 33.0 | Nearly straight grained; various small knots, one larger knot $\frac{3}{4}$ in. diar. 3 ins. from one end. Failed by crippling at this knot; also somewhat sea-oned at heart. |
| 2.90 × 2.90 × 29.35 | 6183 | 32.7 | Straight grained; various small knots, one larger knot $\frac{5}{8}$ in. diar. 9 ins. from end. Failed by crippling at this knot.   |
| 2.75 × 2.88 × 31.50 | 5871 | 36.4 | Straight grained; knot $\frac{3}{4}$ in. diar. 12 ins. from end. Crippled at the knot.  |
| 2.17 × 2.18 × 30.00 | 6174 | 35.0 | Straight grained, clear but for one knot 10 ins. from end $\frac{1}{2}$ in. in diar., Crippled at this knot.  |
| 2.73 × 2.85 × 28.74 | 8124 | 34.8 | Clear and straight grained. Failed by a thin layer bursting out, and then a clean cripple 8 ins. from same end.   |
| 4.69 × 5.84 × 28.10 | 6677 | 31.1 | Clear and straight grained; crippled 8 ins. from end.   |
| 4.17 × 5.00 × 33.70 | 4839 | 32.3 | Straight grained, but heavy knot near end and very heavy knot near centre. Crippled at latter knot.   |
| 4.30 × 5.01 × 32.72 | 5566 | 36.7 | Straight grained, but heavy knot on side near centre; also heavy knot 8 ins. from end one side. Failed at the latter knot.  |

RESULTS OF COMPRESSION TESTS ON NEW DOUGLAS FIR.—*Continued.*

|                     |      |       |  |
|---------------------|------|-------|--|
| 3.95 × 4.33 × 32.28 | 4479 | 30.1  | A great many knots on each end and at various other points. Failed at a large knot 12 ins. from an end. Also heavy season cracks.  |
| 3.98 × 4.10 × 28.65 | 5735 | 34.3  | One old side badly seasoned and injured by usage; also knots near each end; also a small pin knot near centre at which piece failed by crippling and bursting of fibres. |
| 3.93 × 4.30 × 31.95 | 5124 | 32.6  | Heavy knots near centre. Crippled at knots.  |
| 4.11 × 4.92 × 31.85 | 7309 | 35.1  | Clear and straight grained, except slight wave 1 ft. from end due to vicinity of knot. Failed at this point by direct crippling.   |
| 4.22 × 4.92 × 30.84 | 7167 | 39.2  | Clear and straight grained. Crippled 8 ins. from end.  |
| 2.33 × 2.84 × 28.00 | 6496 | 31.7  | Clear and straight grained. Failed by bending 10 ins. from end.  |
| 2.27 × 2.27 × 33.75 | 5708 | 36.0  | Clear, straight grain; ed. Failed by bending-short specimen failed at 30,000 lbs.  |
| 3.96 × 4.18 × 35.25 | 5015 | 36.6  | Several knots; crippled at one running from corner to corner 12 ins. from one end.   |
| 4.20 × 4.50 × 38.00 | 5905 | 35.6  | Grain out of parallel; clear. Failed by bursting and shearing along season cracks.   |
| 3.33 × 3.40 × 33.55 | 7615 | 33.6  | Clear, straight grain. Crippled near one end.  |
| 3.30 × 3.38 × 33.54 | 7444 | 35.6  | Clear and straight grained. Failed by crippling 6 ins. from end.   |
| 3.35 × 3.40 × 33.50 | 5338 | 35.4  | Large knot passing through centre side to side; piece split end to end through this knot.  |
| 3.30 × 3.40 × 33.55 | 5909 | 35.6  | Knot near centre, also two small pin knots near end. Crippled through h pin knots.   |
| 3.30 × 4.00 × 33.50 | 5416 | 35.2  | Large knot near centre passing from side to side. Split from end to end through knot.  |
| 3.30 × 4.00 × 33.50 | 5023 | 32.8  | Large mass of knots near middle. Crippled at these.  |
| 4.25 × 5.75 × 35    | 5729 |       |  |
| 4.25 × 5.87 × 41.75 | 4090 |       |  |
| 4 × 4 × 48          | 4469 | 32.75 | Grain parallel; knot at centre at corner; other knots near end; centre of tree 12 ins. away. Bent at centre at knots concave to a high corner.                           |
| 2.86 × 4.06 × 40.02 | 6330 | 38.1  | Straight grain; small knot 14 ins. from end. Failed by bending in middle.  |
| 4.10 × 4.24 × 41.53 | 3866 | 36.3  | Straight grain; three knots. Crippled at knot 12 ins. from end; no bending.  |
| 4.25 × 4.25 × 54.95 | 3389 | 34.6  | Straight grain; many knots. Burst in two opposite directions at knots 11 ins. from one end and 12 ins. from other end.   |
| 1.99 × 2.64 × 52.62 | 5105 | 34.3  | Straight grain; clear; bent at centre.   |

RESULTS OF COMPRESSION TESTS ON NEW DOUGLAS FIR.—*Continued.*

|                     |      |      |   |
|---------------------|------|------|---|
| 4.26 × 4.33 × 60.0  | 3980 | 35.5 | Straight grain; failed by crippling at knot passing through corner 13 ins. from end and 1.16 in. out of square; no appreciable effect.  |
| 4.09 × 4.34 × 59.0  | 3211 | 34.4 | Straight grain; three or four knots; season crack on one side. Crippled at knot 20 ins. from end and season crack opening.  |
| 4.18 × 4.22 × 59.75 | 3190 | 35.4 | Four knots, two each 18 ins. from ends, several other small knots; grain not straight; large season crack. Failed by shearing and bursting open at season crack across annular rings. |
| 2.46 × 2.51 × 60.5  | 4619 | 34.5 | Straight grain; several knots. Failed by crippling at knot 12 ins. from end.  |

RESULTS OF COMPRESSION TESTS ON  
OLD DOUGLAS FIR.

| Dimension in ins.<br>Lengths. | Breaking<br>Load in lbs.<br>per sq. in. | Weight in lbs.<br>per cub. ft. | Remarks.  |
|-------------------------------|---|--------------------------------|---|
| 2.21 × 2.23 × 9.15            | 8644                                    | 35.9                           | Grain straight and clear; one old side with season crack. Bulged along season crack, and crippled.  |
| 3.45 × 2.78 × 9.65            | 6465                                    | 32.5                           | All fresh sides; straight and parallel grain; one edge strained from bolt. Crippled all over.   |
| 3.41 × 2.78 × 9.65            | 7247                                    | 35.4                           | One old side; grain straight and parallel. Crippled near one end.   |
| 3.41 × 2.80 × 9.70            | 5696                                    | 33.2                           | All fresh sides; grain straight and parallel; one edge strained from bolt; 1 in. season crack. Crippled one-fourth the way down, slightly helped by season crack. |
| 3.38 × 2.78 × 9.65            | 6979                                    | 34.5                           | One old side; grain straight and parallel. Crippled at one end, slightly aided by season crack.   |
| 2.76 × 3.76 × 9.64            | 7235                                    | 35.6                           | One old side; iron stain at one end; season crack; grain straight and parallel. Crippled at 3 ins. from end.  |
| 2.83 × 3.81 × 9.75            | 6577                                    | 32.9                           | One old side; grain straight and parallel. Crippled near centre.  |
| 4.15 × 4.64 × 11.32           | 6660                                    | 35.70                          | Knot 5 ins. from end; next face, knots 1½ ins. and 4 ins. from same end; small pin knot and season crack on third side. Crippled through knots.                   |
| 4.35 × 4.67 × 11.95           | 7900                                    | 47.25                          | Clear and straight; very full of resin; some season cracks; crippled at one end.  |
| 3.40 × 3.47 × 12.00           | 5085                                    | 31.7                           | Grain straight, but slightly curly; three fresh sides; old side crushed by tie; slightly rotten under tie; crippled at small defect near one end.                 |
| 3.45 × 3.45 × 12.00           | 5218                                    | 30.88                          | Grain parallel; crushed and rotten for a depth of ½ in. under tie; two adjacent sides new. Crippled at rotten part near one end.                                  |

## RESULTS OF COMPRESSION TESTS ON OLD DOUGLAS FIR.—Continued.

|                                 |      |      |   |
|---------------------------------|------|------|---|
| $3.45 \times 3.47 \times 12.0$  | 3838 | 35.0 | Grain parallel, but crooked; knot near corner $4\frac{1}{2}$ ins. from end, $1\frac{1}{2}$ ins. dia., knot extended into piece. Crippled through knot.              |
| $3.45 \times 3.47 \times 12.0$  | 4928 | 38.7 | Grain parallel; three fresh sides; $1\frac{1}{4}$ ins. knot passing through corner $5$ ins. from end. Crippled near one end and split along grain adjacent to knot. |
| $3.45 \times 3.45 \times 12.0$  | 5461 | 33.3 | Grain parallel; two adjacent fresh sides; season crack on one old side. Crippled near one end and split slightly along season crack.                                |
| $2.90 \times 2.92 \times 12.0$  | 5314 | 34.0 | Grain parallel; three fresh sides; small season crack. Crippled near one end.   |
| $3.41 \times 3.48 \times 12.0$  | 5308 | 34.9 | Grain parallel; three fresh sides; knot hole on one corner $3\frac{1}{2}$ ins. long, $0".8$ in. deep; also season cracks. Failed by opening of season cracks.       |
| $3.42 \times 3.47 \times 12.0$  | 4011 | 30.0 | Grain parallel; three fresh sides; old side slightly damaged; also cant. hook holes. Crippled near centre at cant. hook holes.                                      |
| $3.42 \times 3.45 \times 12.0$  | 4814 | 32.0 | Grain parallel; two fresh sides; slightly rotten at one end on old side. Crippled at the rotten point.  |
| $3.45 \times 3.46 \times 12.0$  | 5053 | 30.5 | Straight grain; all fresh sides; shows signs of failure; crack at end. Crippled near one end.   |
| $2.88 \times 2.87 \times 12.0$  | 6199 | 33.2 | Grain sound and parallel; three fresh sides. Crippled near one end.   |
| $3.44 \times 3.46 \times 12.0$  | 5703 | 33.6 | Grain parallel; two adjacent fresh sides; season cracks; small cant. hook hole $2$ ins. from end close to corner; slightly rotten. Crippled at cant. hook mark.     |
| $3.46 \times 3.46 \times 12.0$  | 5693 | 33.8 | Grain parallel; three fresh sides; small season crack on one side. Crippled at one end; season crack opened.  |
| $2.82 \times 3.40 \times 12.05$ | 6611 | 32.7 | Parallel grain; four fresh sides. Crippled near one end.  |
| $2.77 \times 3.36 \times 12.0$  | 7519 | 35.3 | Parallel grain; one old side; saw cut and season crack. Crippled near one end.  |
| $2.80 \times 3.40 \times 12.03$ | 6813 | 32.5 | All fresh sides; grain straight and parallel; $1$ in. season crack. Split along season crack.   |
| $2.79 \times 3.35 \times 12.03$ | 6845 | 34.6 | One old side; season cracks; grain straight and parallel. Split along season crack.   |
| $2.79 \times 3.91 \times 12.03$ | 7149 | 34.6 | One old side; grain straight and parallel. Crippled at one end.   |
| $2.78 \times 3.73 \times 12.04$ | 7348 | 35.5 | One old side; grain straight and parallel; season cracks $1$ in. deep. Crippled at one end.   |
| $2.77 \times 3.86 \times 12.05$ | 7390 | 33.5 | One old side; grain straight and parallel. Crippled near centre at a small defect.  |

RESULTS OF COMPRESSION TESTS ON OLD DOUGLAS FIR.—*Continued.*

|                                 |      |       |   |
|---------------------------------|------|-------|---|
| $2.80 \times 3.80 \times 12.06$ | 7481 | 34.1  | One old side; grain straight and parallel. Crippled at end.   |
| $2.78 \times 3.88 \times 12.0$  | 7090 | 34.2  | One old side; grain straight and parallel. Crippled near one end.   |
| $2.79 \times 3.06 \times 12.0$  | 7317 | 33.4  | One old side; grain straight and parallel. Crippled at 3 ins. from end.   |
| $3.27 \times 3.95 \times 12.0$  | 5540 | 33.45 | Grain straight and clear, except small pin knot hole 3 ins. from end; piece shivered by season cracks. Failed by piece splitting off. It then crippled at knot 3 ins. from one end.   |
| $3.28 \times 3.96 \times 12.$   | 5510 | 32.9  | Grain straight; small pin knot on a corner near centre; very heavy season crack on old side. Burst along season crack; also crippled 4 ins. from one end.   |
| $3.32 \times 4.04 \times 12.0$  | 4825 | 28.85 | Grain straight; pin knot on corner near centre; heart decayed; also one season crack. Crippled at pin knot.   |
| $3.31 \times 4.02 \times 12.04$ | 5675 | 32.85 | Grain straight; small pin knot $\frac{1}{2}$ ins. from end; two bad season cracks. Crippled square across near each end.  |
| $3.33 \times 4.0 \times 12.0$   | 4165 | 28.95 | Grain not quite straight; knot at corner 2 ins. from end; deficiency of heart all along one edge. Crippled at knot.   |
| $3.30 \times 4.0 \times 12.0$   | 6300 | 33.55 | Straight grain; knot on corner $\frac{1}{2}$ ins. from end; large deficiency on opposite corner at other end; another deficiency and nail gouge at centre of same edge; also one season crack. Crippled at knots.   |
| $3.28 \times 4.02 \times 12.03$ | 5540 | 32.70 | Straight grain; knot on corner $\frac{1}{2}$ ins. from end; also season cracks. Crippled 4 ins. from end.   |
| $4.18 \times 4.63 \times 12.22$ | 5200 | 35.3  | Knots 3 ins. and 6 ins. from end on same side; also small knot on next face 1 in. from same end; also part of large knot on other end. Failed longitudinally through two knots; upper end was not horizontal, not more than 5-6 tns. of the area bearing. |
| $4.35 \times 4.65 \times 14.15$ | 6735 | 36.95 | Two knots 2 ins. and 6 ins. from end on same side; also knot on next face 3 ins. from same end and two knots on other end; on third and fourth faces, knots $\frac{1}{2}$ ins. and 4 ins. from first end. Crippled at knot 3 ins. from end.               |
| $4.25 \times 4.65 \times 14.80$ | 7085 | 36.6  | Two knots passing through from face to next face; one 3 ins. from end; the other 7 ins. from same end; deficiency 1 in. $\times$ $1\frac{1}{4}$ in. on opposite edge. Crippled through knot 7 ins. from end.  |

RESULTS OF COMPRESSION TESTS ON OLD DOUGLAS FIR.—*Continued.*

|                                 |      |       |   |
|---------------------------------|------|-------|---|
| $4.39 \times 4.70 \times 14.78$ | 6500 | 45.70 | Full of resin; part of large knot on one end; season crack on one face; shaken on a corner. Crippled in solid wood (in resin part) 4 ins. from end.   |
| $4.14 \times 4.65 \times 14.80$ | 6730 | 41.0  | Patch of resin through centre; knot on one corner 6 ins. from end; slight season cracks; slight deficiency on one corner. Crippled through knot.  |
| $4.25 \times 4.66 \times 14.78$ | 6020 | 37.4  | One medium knot 1 in. from end; also many small knots on same face; on next face, knots at 6 ins. and 1 in. from same end. Failed through knots at the centre.                                  |
| $4.16 \times 4.60 \times 14.50$ | 7410 | 35.7  | Part of large knot on one end; one side covered with small knots; otherwise sound specimen. Failed at large knot at end.  |
| $4.28 \times 4.70 \times 14.78$ | 7490 | 36.2  | Grain parallel; one medium knot 5 ins. from end; also two small knots 1 in. from same end and on same side; also heart shake. Failed at centre by crippling through small knot.                 |
| $4.17 \times 4.70 \times 14.78$ | 6400 | 34.0  | Grain parallel; mass of knots at one end; also badly seasoned in resinous portion. Crippled at knotty end.  |
| $4.35 \times 4.74 \times 14.80$ | 6310 | 47.0  | Grain parallel; large knot near one end; bad season cracks in resinous portion. Crippled at large knot.   |
| $4.27 \times 4.67 \times 14.80$ | 7310 | 37.2  | Grain straight and sound, but one large knot on end; also one knot on an edge 3 ins. from end; one knot 5 ins. from other end on same edge; slight season cracks. Failed at the two last knots. |
| $4.14 \times 4.57 \times 14.75$ | 6960 | 35.45 | Knots in each end; otherwise clear; two old sides badly shaken. Crippled and burst at knot at one end.  |
| $4.32 \times 4.70 \times 14.80$ | 5970 | 38.05 | Groups of small knots about 3 ins. from each end; also full of resin. Crippled at each end through knots.   |
| $4.14 \times 4.60 \times 14.80$ | 6580 | 35.05 | Groups of small knots about 4 ins. from each end; also bad season cracks. Crippled through one group of knots.  |
| $4.06 \times 4.65 \times 14.85$ | 6500 | 43.70 | Large knot at one end; two knots 5 ins. from other end; full of resin; dense and heavy; one season crack. Crippled through both knots 5 ins. from end.  |

## RESULTS OF COMPRESSIVE TESTS ON

## RED PINE.

| Dimensions<br>in inches.        | Lengths<br>in<br>inches | Compressive<br>Strength<br>in lbs. per<br>sq. inch. | Weight<br>in lbs. per<br>cub. ft. | Remarks.  |
|---------------------------------|-------------------------|---|-----------------------------------|---|
| 4.96 in diar. $\times$ 5.9      |                         | 2497  |                                   | Failed at knots 26 ins.<br>from end; also at an-<br>other ring of knots 3 ins.<br>from same end; nine-<br>teen knots in length.   |
| 4.97 in diar. $\times$ 5.8      |                         | 2742  |                                   |   |
| 2.98 " " $\times$ 5.86          |                         | 2722  |                                   |   |
| 3.00 " " $\times$ 5.9           |                         | 2631  |                                   |   |
| 2.95 in diar. $\times$ 5.65     |                         | 6870  |                                   | One knot near one end.<br>Failed by crippling<br>above knot.  |
| 2.88 in diar. $\times$ 5.69     |                         | 7057  |                                   | Clear. Crippled 6 ins<br>from one end.  |
| 4.81 in diar. $\times$ 13.75    |                         | 5092  |                                   | Clear grain. Failed by<br>spreading at bottom.  |
| 3.88 in diar. $\times$ 13.5     |                         | 7602  | 39.9                              | Nearly straight grain;<br>knot 6 ins. from end<br>passing nearly through<br>centre. Failed at the<br>knot by crippling.   |
| 3.80 diar. $\times$ 13.31       |                         | 6438  | 35.8                              | Straight grained; knot<br>on one end. Failed by<br>crippling at knot about<br>$\frac{1}{2}$ in. from end all around   |
| 4.02 in diar. $\times$ 18.75    |                         | 4657  |                                   | Clear wood; straight<br>grained; spread at end,<br>due to curvature of fibre<br>in locality of a knot.  |
| 3.90 " $\times$ 18.20           |                         | 7222  | 35.7                              | Clear and straight<br>grained. Failed 6 ins.<br>from end by folding.  |
| 3.66 " $\times$ 22.61           |                         | 8516  | 43.2                              | Grain parallel; one<br>knot 10 ins. from end.<br>Failed through knot by<br>crippling.   |
| 4.01 in diar. $\times$ 22.73    |                         | 5637  | 28.7                              | Four knots at 8 ins.<br>from one end. Failed by<br>crippling at knots.  |
| 4.3 in diar. $\times$ 22.8      |                         | 5983  | 26.7                              |   |
| 3.93 in diar. $\times$ 29.2     |                         | 7914  | 38.1                              | Grain parallel; two<br>knots, one large knot 10<br>ins. from one end. Fail-<br>ed by crippling at this<br>knot.   |
| 6.93 " $\times$ 36.12           |                         | 2698  |                                   | Failed by crushing at<br>knot, 4 ins. from end.<br>Fourteen knots in<br>length.   |
| 7.02 " $\times$ 36.12           |                         | 2087  |                                   | Failed at knot 8 $\frac{1}{2}$ ins.<br>from end; ten knots in<br>length.  |
| 7.01 " $\times$ 36.12           |                         | 2024  |                                   | Failed at ring of knots<br>7 ins. from end; fifteen<br>knots in length.   |
| 3.97 " $\times$ 3.10            |                         | 3287  |                                   | Crushed and failed at<br>knot; straight grain;<br>fairly free from knots.   |
| 4.10 " $\times$ 3.10            |                         | 2825  |                                   | Failed by crushing<br>and bending. Straight<br>grain; crack down<br>length.   |
| 4.04 " $\times$ 3.10            |                         | 3482  |                                   |   |
| 4.03 " $\times$ 3.10            |                         | 4247  |                                   |   |
| 3.98 " $\times$ 3.10            |                         | 3223  |                                   |   |
| 3.96 " $\times$ 3.10            |                         | 4001  |                                   |   |
| 4.75 $\times$ 4.75 $\times$ 60. |                         | 3104  |                                   |   |
| 3.97 in diar. $\times$ 69.      |                         | 2585  | .985                              | Not well seasoned.<br>Failed by crushing and<br>bending at a large knot<br>31 ins. from end; also<br>at 1 in. from end and 4 $\frac{1}{2}$<br>ins. from other end;<br>straight grained; six<br>knots in whole length. |
| 4.08 " $\times$ 69.             |                         | 2593  |                                   | Failed at ring of knots<br>four in number by crush-<br>ing and bending at 24<br>ins. from end; also at 2<br>ins. from same end;<br>fourteen knots in whole<br>length.   |

RESULTS OF COMPRESSION TESTS ON RED PINE.—*Continued.*

|                    |      |   |
|--------------------|------|---|
| 4.02 in diar. × 69 | 3152 | Failed by crushing; straight grained; failed at two small knots 27 ins. from end and also at 16 ins. from same end; large knots 39 ins. from same end; ten knots in length. |
| 3.91 " × 69        | 3280 | Failed by crushing 16 ins. from one end at a knot. Twelve knots in whole length.  |
| 4.03 " × 69        | 3158 | Failed chiefly by crushing 12 ins. from one end; four knots in length.  |
| 3.96 " × 69        | 3734 | Failed at knot 24 ins. from end; six knots in length; also crippled 1 inch from same end.   |
| 4.94 " × 66.25     | 2386 | Failed at knots 26 ins. from end; also at another ring of knots 3 ins. from same end; nineteen knots in length.   |
| 4.92 " × 66.25     | 2513 | Failed at ring of knots 36 ins. from end; sixteen knots in length.  |
| 2.96 " × 66        | 1977 | Failed by crushing and bending at large knot 28 ins. from end, eight knots in length.   |
| 3.06 " × 66.25     | 2433 | Failed by crushing at knots 5 ins. from end. Four knots in whole length.  |

RESULTS OF COMPRESSIVE TESTS ON  
NEW WHITE PINE.

| Dimensions<br>in inches | Lengths<br>in<br>inches. | Compr'sve<br>Strength<br>in lbs. per<br>sq. inch. | Weight<br>in lbs.<br>per cub. ft. | Remarks.  |
|-------------------------|--------------------------|---|-----------------------------------|---|
| 4.187 × 2.44 × 2.31     |                          | 3810  |                                   |   |
| 4.687 × 2.312 × 2.44    |                          | 2955  |                                   |   |
| 4.812 × 2.312 × 2.44    |                          | 4248  |                                   |   |
| 3.0 × 2.94 × 2.98       |                          | 5352  | 24.4                              |   |
| 4.75 × 4.75 × 3.        |                          | 3821  |                                   |   |
| 4.8 × 4.8 × 4.6         |                          | 3515  |                                   |   |
| 4.75 × 4.75 × 4.6       |                          | 4387  |                                   |   |
| 4.75 × 4.80 × 4.53      |                          | 3280  |                                   |   |
| 4.75 × 4.44 × 4.50      |                          | 3449  |                                   |   |
| 4.75 × 4.78 × 4.36      |                          | 4361  |                                   |   |
| 4.75 × 4.75 × 4.37      |                          | 4433  |                                   |   |
| 4.75 × 4.75 × 4.40      |                          | 4363  |                                   |   |
| 4.75 × 4.70 × 4.50      |                          | 3449  |                                   |   |
| 4.75 × 4.80 × 4.53      |                          | 3193  |                                   |   |
| 4.75 × 4.75 × 4.37      |                          | 3972  |                                   |   |
| 4.75 × 4.75 × 5.        |                          | 3548  |                                   |   |
| 4.75 × 4.75 × 10.375    |                          | 2826  | 30.3                              | Grain clear but not straight. Cracked down one side.                          |
| 3.01 in diam. × 11.35   |                          | 4382  | 26.7                              | Clear and straight. Failed by folding near one end.                           |
| 4.75 " × 11.125         |                          | 3500  | 21.60                             | Clear grained, but not straight. Failed by folding over at top.               |
| 4.75 " × 11.875         |                          | 5527  | 27.50                             | Clear specimen; deep season cracks across annular rings. Failed by crippling. |
| 4.812 " × 12.25         |                          | 3990  | 23.80                             | Two large knots. Failed between them.   |
| 3.00 " × 12.80          |                          | 3762  | 29.4                              | Two heavy knots 2 ins. from end. Failed by crippling at the knots.            |
| 4.75 × 4.75 × 12.156    |                          | 5383  | 26.5                              | Clear specimen. Crippled without bulging or cracking.                         |
| 2.98 × 2.98 × 12.0      |                          | 5574  | 29.4                              | Clear and straight grained. Failed by crippling.                              |

RESULTS OF COMPRESSIVE TESTS ON NEW WHITE PINE.—*Continued.*

|                                      |      |       |   |
|--------------------------------------|------|-------|---|
| 4.71 in. diar. $\times$ 13.12        | 2774 |       | Ring of four knots 6 ins. from one end. Failed by crippling at knots.   |
| 4.71 in. diar. $\times$ 14.562       | 3400 | 20.6  | One knot and also signs of decay. Failed by crippling at the knot.  |
| 2.625 $\times$ 3.562 $\times$ 14.125 | 6400 |       | Clear.  |
| 4.72 $\times$ 4.72 $\times$ 14.875   | 5004 | 26.3  | Clear. Crippled without cracking or bulging.  |
| 4.75 in. diar. $\times$ 14.75        | 4408 |       | One large knot; decayed near heart. Failed at knot.   |
| 4.71 in. diar. $\times$ 15.5         | 3360 | 21.1  |   |
| 4.703 " $\times$ 15.35               | 3861 | 26.60 | One knot at bottom of specimen. Failed at this knot by crippling.   |
| 2.94 " $\times$ 15.30                | 4272 | 26.5  | Clear and straight, but deep injury from pike pole. Failed at injured part.   |
| 4.75 in. diar. $\times$ 16.          | 4463 |       |   |
| 3.87 " $\times$ 16.25                | 2973 | 29.9  | Straight grained. Failed at one end at a large knot.  |
| 4.75 " $\times$ 17.35                | 4232 | 26.40 | Two large knots. Failed between them.   |
| 4.71 " $\times$ 17.938               | 4847 | 27.1  | Clear and straight grained. Failed at end.  |
| 4.40 $\times$ 4.40 $\times$ 17.0     | 3856 | 30.6  | Three large knots in a ring around specimen. Failed at knots.   |
| 2.97 $\times$ 3.85 $\times$ 20.54    | 6036 | 30.1  | Clear and straight grained; one-third sapwood. Failed by crippling at 7 ins. from one end.  |
| 3.85 $\times$ 3.83 $\times$ 21.65    | 3933 | 26.1  | Failed previously as pillar under 49,200 lbs. Crippled now at a large knot 8 ins. from end.   |
| 3.8 " $\times$ 3.8 " $\times$ 22.35  | 3808 | 26.7  | Two large knots. Crippled at one, 2 ins. from an end.   |
| 3.83 $\times$ 3.83 $\times$ 23.82    | 3615 | 25.9  | Failed by crippling at two knots near centre.   |
| 2.97 $\times$ 2.99 $\times$ 23.60    | 5462 | 24.9  | Clear and straight grained; failed previously as pillar under 42,000 lbs. Crippled now near centre.   |
| 3.02 diar. $\times$ 25.79            | 5023 | 24.5  | Clear and straight grained. Failed by crippling 8 ins. from one end.  |
| 3.40 $\times$ 3.80 $\times$ 25.4     | 3610 | 25.0  | Straight grained; bad season cracks; full of knots, failed by crippling through two of them 8 ins. from end.  |
| 2.98 $\times$ 2.99 $\times$ 24.25    | 4607 | 23.9  | Straight grained; pin knot 10 ins. from one end. Failed by crippling and bending at pin knot.   |
| 2.95 $\times$ 3.25 $\times$ 26.70    | 3508 | 24.1  | Straight grained, but full of knots. Crippled at one near corner in middle.   |
| 4.75 $\times$ 4.75 $\times$ 21.0     | 3103 |       | Clear; grain 2 ins. out of parallel; season cracks along grain. At upper corner grain ran out. Failed by sliding along seasoning, due to non support of fibres running from corner. |
| 2.99 $\times$ 2.99 $\times$ 24.08    | 4474 | 26.7  |   |
| 3.05 in. diar. $\times$ 24.1         | 5240 | 25.8  | Clear and straight grained. Failed by crippling and bending at same instant at middle.  |
| 3.46 $\times$ 4.33 $\times$ 27.00    | 3488 | 20.4  | Failed previously as pillar under 33,300 lbs. Failed now at knot 8 ins. from end on a side.   |
| 2.92 in. diar. $\times$ 36.53        | 5269 | 29.8  | Clear and straight grained; one-third sapwood. Fail by crippling on sapwood side and then bending afterwards 12 ins. from end.  |

RESULTS OF COMPRESSIVE TESTS ON NEW WHITE PINE.—*Continued.*

|                      |      |      |  |
|----------------------|------|------|--|
| 3.05 in diar. × 48.0 | 4377 | 25.9 | Clear grain, $1\frac{1}{2}$ in. out of straight; high at one side. Failed by bending 20 ins. from one end on high side.  |
| 3. × 3. × 48.0       | 4666 | 25.0 | Ten knots; long season crack ran three fourths the way down, $1\frac{1}{2}$ ins. deep and $\frac{1}{2}$ in. from edge; a bruise 3 ins. from end on same side; on opposite side, crack 3 ins. long, 1 in. deep; grain and rings both parallel. Failed by bending toward a high corner and then crippling. |
| 4.75 in diar. × 60   | 2652 |      |  |
| 4.75 in diar. × 60   | 1862 |      |  |
| 4.75 × 4.75 × 60     | 2749 |      |  |
| 4.75 × 4.75 × 60     | 1862 |      |  |
| 4.75 × 4.75 × 60     | 1951 |      |  |
| 4.75 × 4.75 × 60     | 1951 |      |  |
| 4.75 × 4.75 × 60     | 2306 |      |  |
| 4.75 in diar. × 61   | 2676 |      |  |
| 4.62 × 4.75 × 60     | 2370 |      |  |
| 4.62 × 4.75 × 60     | 2826 |      |  |
| 4.75 in diar. × 60   | 2765 |      |  |
| 4.00 × 4.00 × 78.24  | 2937 | 27.6 | Heart; unseasoned straight grain; four groups of knots 2 in. $3\frac{1}{2}$ ins., $4\frac{1}{2}$ ins., $5\frac{1}{2}$ ins. from end on each face. Crippled and failed through knot 2 ins. from end on low side.  |
| 4.03 × 4.06 × 78.2   | 3466 | 28.7 | Straight grain; several knots. Failed by bending at knot 30 ins. from one end. Ends square; maximum load 70,500 lbs.   |
| 4.03 × 4.03 × 75     | 4557 | 28.2 | Straight clear grain; one small knot. Failed at knot 3 ft. 4 ins. from end; crippled, then split open; ends square.  |
| 3.95 × 3.98 × 75     | 3260 | 29.3 | Grain straight but for frequent knots; failed at a group of knots about 2 ft. from one end by splitting, first slightly open and then crippling on one side; it bent afterwards.   |

RESULTS OF COMPRESSIVE TESTS ON

OLD WHITE PINE.

| Dimensions in inches. | Lengths. | Compressive Strength in lbs. per sq. inch. | Weight per cub. ft. in lbs. | Remarks.   |
|-----------------------|----------|--|-----------------------------|--|
| 3.5 × 4.4 × 11.75     |          | 1980                                       | 27.35                       | Large knots on all sides about 2 ins. from an end, otherwise in good condition, except shivered at a corner between two knots. Failed by splintering at shivered corner; also crippled at knots. |
| 3.4 × 4.3 × 11.70     |          | 2740                                       | 28.10                       | A large knot appearing on two faces 3 ins. from end; also a slight season crack on one face. Failed by splitting longitudinally along season crack.  |
| 3.46 × 4.32 × 11.75   |          | 4470                                       | 26.45                       | Medium knot through corner showing on two faces about $1\frac{1}{2}$ ins. from end; otherwise sound and clear. Failure by crippling at centre.   |

RESULTS OF COMPRESSIVE TESTS ON OLD WHITE PINE.—*Continued.*

|                                 |      |       |   |
|---------------------------------|------|-------|---|
| $3.50 \times 4.25 \times 11.74$ | 3850 | 26.30 | Knot on a face $1\frac{1}{2}$ ins. from end, passing to opposite face $\frac{1}{2}$ in. from end; also small deficiency at corner on same end and along one edge; also sapwood. Crippled longitudinally through knot. |
| $3.45 \times 4.39 \times 11.77$ | 4115 | 25.35 | One small pin knot on corner; also shaken by seasoning; also two small injuries on an edge. Burst at the season cracks; afterwards crippled.  |
| $3.50 \times 4.41 \times 11.75$ | 2735 | 25.55 | Two large knots at an end on opposite faces 2 ins. from end; also slight season cracks. Crippled at knots.  |
| $3.47 \times 4.38 \times 11.75$ | 4330 | 26.50 | Clear and nearly straight grained; slightly shaken by season cracks. Crippled 5 ins. from one end.  |
| $3.52 \times 4.37 \times 11.75$ | 2625 | 28.55 | A large knot 3 ins. from end passing through from opposite faces; also seasoned somewhat. Crippled through at knot.   |
| $3.45 \times 4.25 \times 11.75$ | 4660 | 23.3  | Clear specimen, except deficiency at a corner, partly sapwood; also bad injury (spike hole) in deficient corner. Crippled at centre.  |
| $3.45 \times 4.36 \times 11.70$ | 3975 | 24.5  | Two weathered sides: clear; seasoned. Clear crippled at centre.   |
| $3.50 \times 4.27 \times 11.70$ | 4695 | 25.0  | One old side; clear shaken by season cracks. Crippled at centre.  |
| $3.49 \times 4.37 \times 11.75$ | 4230 | 25.8  | Grain clear and straight, large cant. hook hole 1 in. from one end on old narrow side. Failed by crippling at centre.   |
| $3.48 \times 4.32 \times 11.73$ | 3910 | 24.4  | Large knot on end; seasoned; grain clear and straight. Failed by crippling at centre.   |
| $3.48 \times 4.40 \times 11.74$ | 3830 | 23.85 | Large knot on end; grain clear and straight, season cracks. Failed by splitting longitudinally and crippling slightly at centre.  |
| $3.51 \times 4.30 \times 11.60$ | 4525 | 25.65 | One old side; grain clear and straight; piece badly shaken. Crippled at centre.   |
| $4.10 \times 4.16 \times 12.00$ | 2923 | 23.2  | Grain clear and straight; season cracks on two old sides; injured by cant. hook on one old side. Crippled at one end and through defect.  |
| $4.21 \times 4.19 \times 12.00$ | 2183 | 23.0  | Grain parallel; one small pin knot; season cracks on old side; one small defect on corner 2 ins. from end. Crippled at one end.   |
| $4.17 \times 4.18 \times 12.05$ | 2059 | 25.4  | A large knot near centre; badly seasoned on old side; split along seasoning; split from knot. Also crippled.  |
| $4.14 \times 4.22 \times 12.00$ | 2840 | 22.9  | Grain clear and straight, seasoning cracks through centre; small defect on old side. Crippled through defects.  |

**RESULTS OF COMPRESSIVE TESTS ON OLD WHITE PINE.—Continued.**

|                     |      |       |  |
|---------------------|------|-------|--|
| 4.19 × 4.20 × 12.00 | 1716 | 32.5  | A large knot from end to end along one face; another at one end; another at opposite side. Fibre split from knot.  |
| 4.18 × 4.22 × 12.00 | 2228 | 26.3  | A large knot from end to end along one face; another at one end. Crippled at knot at centre, and also a splitting away.  |
| 4.14 × 4.18 × 12.00 | 2794 | 23.1  | Clear and straight; seasoned on two old sides. Crippled at one end.  |
| 4.17 × 4.19 × 12.00 | 1723 | 25.0  | Grain clear and straight, bad season cracks on old side; spike hole 2½ ins. deep, 2 ins. from one end. Failed at spike hole.   |
| 4.21 × 4.21 × 12.00 | 2257 | 22.3  | Grain straight; three fresh sides; one large knot near end; season cracks on old side. Crippled through knot at one end.   |
| 4.20 × 4.22 × 12.00 | 2438 | 23.6  | Grain straight; two large knots at opposite ends; season cracks on old side. Crippled on end at a knot.  |
| 4.16 × 4.21 × 12.00 | 2569 | 23.4  | Grain straight and parallel, except at one end, where it is curled by vicinity of a knot; otherwise sound. Crippled at sound end.  |
| 4.19 × 4.22 × 12.00 | 2030 | 28.0  | Two large knots at one end, otherwise straight and clear; fresh sawn on all sides. Crippled at knots at end.   |
| 4.13 × 4.20 × 12.00 | 2686 | 24.1  | Grain straight; three small knots at centre; two old sides injured by several small holes. Fibre split and crippled at small knots.  |
| 4.17 × 4.18 × 12.00 | 2180 | 25.3  | Three large knots at centre; grain parallel; full of season cracks on old side; fibre split. Crippled at knots.  |
| 4.20 × 4.21 × 12.00 | 1833 | 24.4  | Grain crooked by knots; two large knots near centre; large season crack on one old side. Crippled across centre at knots.  |
| 4.21 × 4.23 × 12.00 | 1915 | 25.0  | Four large knots near centre, otherwise clear and straight; one knot at each corner. Crippled across centre at knots.  |
| 4.16 × 4.21 × 12.00 | 2512 | 23.39 | Grain straight; three sides fresh sawn; small pin knot; small defect at one end on old side. Crippled at and near small defect.  |
| 4.20 × 4.23 × 12.00 | 2277 | 26.1  | A large knot hole at an end; three smaller knots near centre; otherwise sound and straight. Crippled at end aided by knot.   |
| 4.18 × 4.23 × 12.03 | 1838 | 27.2  | Two sides fresh sawn; three large knots 2 ins. to 4 ins. from one end; grain twisted; three cant. hook marks; cracks in medullary rays. Failed by splitting from large knot. |

RESULTS OF COMPRESSIVE TESTS ON OLD WHITE PINE.—*Continued.*

|                                   |      |      |  |
|-----------------------------------|------|------|--|
| $4.20 \times 4.23 \times 12.01$   | 2477 | 25.0 | Three sides fresh sawn; grain not parallel, owing to a knot; one season crack on old side; wood decaying somewhat; several small pin knots. Sheared along season crack, caused by adjacent knot. |
| $4.19 \times 4.22 \times 12.05$   | 2177 | 26.4 | Three fresh sawn sides; two large knots near centre; one pin knot; grain parallel; very large season cracks. Split along season cracks.  |
| $4.20 \times 4.25 \times 12.04$   | 2387 | 26.1 | Four sides fresh sawn; grain parallel; season cracks are through specimen; one large and two small knots at one end, large one at corner. Crippled at knots.                                     |
| $4.17 \times 4.20 \times 12.02$   | 2752 | 24.7 | Three sides fresh sawn; grain not parallel; season cracks through body of specimen; slightly decayed on one side; several small pin knots. Sheared on rot line and crippled at knots.            |
| $4.21 \times 4.23 \times 12.02$   | 1797 | 26.7 | All sides fresh sawn; two large knots in body; grain parallel; slight decay; cracks in medullary rays. Crippled through knots.   |
| $4.18 \times 4.20 \times 12.05$   | 1789 | 25.0 | Two sides fresh sawn; grain not quite parallel; large knot at one end; season cracks on two old sides; small knot in body. Crippled through knots.   |
| $4.19 \times 4.22 \times 12.05$   | 2099 | 24.8 | Three sides fresh sawn; grain parallel; season cracks on old side; two small injuries in old side near one end. Crippled through very small knot near one end.                                   |
| $4.21 \times 4.22 \times 12.01$   | 2251 | 27.3 | Three fresh sides; specimen full of knots, two at one end, one large knot and two small knots in body; bad season crack on old side. Crippled through knot at one end.                           |
| $4.17 \times 4.24 \times 12.02$   | 1606 | 28.0 | Four fresh sides; two large knots near centre; two pin knots; grain parallel. Crippled and split along fibre from the knots.   |
| $4.18 \times 4.20 \times 12.0$    | 2033 | 25.4 | Three sides fresh sawn; large knot 4 ins. from end; grain parallel; slight decay. Crippled opposite knot.  |
| $4.20 \times 4.22 \times 12.0$    | 2499 | 25.9 | Four sides fresh sawn; large knot near centre; grain parallel. Crippled opposite knot.   |
| 3.82 in diam. $\times 13.65$      | 5770 | 30.3 | Clear and straight grained. Failed by folding through an injury from cant. hook $4\frac{1}{2}$ ins. from end.  |
| $3.625 \times 4.50 \times 40.875$ | 2390 | 22.4 | Grain straight; one old side; free from large knots; failed by bursting open along three lines, which pass through various knots and season cracks.  |

RESULTS OF COMPRESSIVE TESTS ON OLD WHITE PINE.—*Continued.*

|                                  |      |       |  |
|----------------------------------|------|-------|--|
| $3.75 \times 4.31 \times 45.25$  | 2970 | 23.6  | Grain straight; one old seasoned side; several knots; failed at one large knot in middle of pillar, which passed through from side to side. Failure by bending across narrow dimension.  |
| $3.50 \times 4.50 \times 45.125$ | 1840 | 22.6  | Grain straight; one old seasoned side; many knots; failed at one large knot in middle of pillar, which passed through from side to side. Failure by bending across narrow dimension.   |
| $3.50 \times 4.38 \times 44.5$   | 2170 | 21.9  | Grain straight; one old side; many small knots; one large knot on old side 15 ins. from one end. Failed by crippling at that knot.   |
| $3.73 \times 4.35 \times 44.5$   | 2650 | 23.6  | Straight grain; fairly clear; some small knots; one old seasoned side. Failed by bending 18 ins. from one end in clear wood across least dimensions.   |
| $3.5 \times 4.4 \times 45$       | 3346 | 22.8  | Grain straight; two old sides; knot at one end; also knot at centre passing through a corner. Failed by direct crippling which started at knot in middle of the piece.   |
| $3.5 \times 4.4 \times 42.5$     | 2082 | 21.1  | Grain nearly straight; one old side; various knots, particularly one near centre passing from corner to corner of section. Failure by bending at this knot on least dimension.   |
| $3.5 \times 4.45 \times 46$      | 2248 | 21.7  | Grain straight; one old side. Failed near centre by bending across least dimension at a knot, which penetrated the heart of piece from one side.   |
| $3.83 \times 3.83 \times 71.3$   | 2862 |       | Two knots on one edge; one large knot at centre, another 12 ins. away; on second face five knots, two near centre, others 12 ins. from ends; grain parallel; centre of tree in corner of specimen, failed by bending at centre knot, induced first by being $\frac{1}{2}$ in. off centre on top bearing. |
| $3.84 \times 3.84 \times 72.0$   | 3338 | 26.06 | Bad knot 6 ins. from centre on one face; next face knot 2 ins. from end; grain about parallel; many smaller knots; centre of tree on same corner as large knot. Failed by bending at large knot.   |

RESULTS OF COMPRESSIVE TESTS ON  
NEW SPRUCE (B.C.)

| Dimensions in inches. | Lengths. | Compressive Strength in lbs. per sq. inch. | Weight in lbs. per cent. ft. | Remarks.  |
|-----------------------|----------|--|------------------------------|---|
| 4.72 X 2.343 X 1.94   |          | 3415                                       |                              |   |
| 4.77 X 2.25 X 1.9     |          | 2941                                       |                              |   |
| 4.75 X 2.375 X 1.875  |          | 3020                                       |                              |   |
| 4.72 X 2.25 X 1.875   |          | 3465                                       |                              |   |
| 4.78 X 2.25 X 1.97    |          | 3256                                       |                              |   |
| 4.75 X 2.25 X 1.94    |          | 3118                                       |                              |   |
| 4.75 X 2.312 X 1.88   |          | 3009                                       |                              |   |
| 4.72 X 2.22 X 1.9     |          | 3179                                       |                              |   |
| 3.75 X 2.34 X 1.62    |          | 3854                                       |                              |   |
| 4.812 X 2.312 X 1.94  |          | 3210                                       |                              |   |
| 4.375 X 1.875 X 2     |          | 4440                                       |                              |   |
| 4.75 X 2.25 X 2.50    |          | 3321                                       |                              |   |
| 4.73 X 4.73 X 3.9     |          | 3451                                       |                              |   |
| 3.67 X 3.67 X 3.64    |          | 5590                                       |                              | Failed by crippling.  |
| 4.75 X 4.75 X 4.0     |          | 3325                                       |                              |   |
| 4.75 X 4.75 X 4       |          | 2838                                       |                              |   |
| 4.812 X 4.812 X 4     |          | 2986                                       |                              |   |
| 4.65 X 4.65 X 5.20    |          | 4540                                       |                              |   |
| 3.00 X 2.875 X 6.50   |          | 7566                                       |                              | Clear and straight.   |
| 3.00 X 3.125 X 6.00   |          | 6036                                       |                              |   |
| 4.7 X 4.7 X 7.75      |          | 4299                                       | 29.80                        | Four pin knots; ends not quite parallel.  |
| 3.125 X 2.875 X 7.25  |          | 6812                                       |                              |   |
| 4.687 X 4.687 X 8.66  |          | 5305                                       | 29.80                        | Clear and sound; cracks along medullary rays.   |
| 4.75 X 4.75 X 11.5    |          | 4656                                       |                              | Clear and straight.   |
| 4.2 X 3.8 X 11.5      |          | 4806                                       | 25.9                         | Crippled at centre.   |
| 4.0 X 4.04 X 11.75    |          | 3898                                       | 33.8                         | Straight grained. Crippled at large knot on edge near centre.   |
| 4.10 X 4.10 X 12.55   |          | 4451                                       | 28.3                         | Clear and straight grained; slight axe-cut on one face 3 ins. from end Failed by crippling at axe cut.                    |
| 3.75 X 3.75 X 12.05   |          | 4907                                       | 29.5                         | Crippled at a bunch of five knots.  |
| 4.72 X 4.72 X 14.09   |          | 4063                                       | 30.2                         | Five large knots and one large season crack.  |
| 4.75 in diam. X 14.   |          | 3328                                       |                              | Clear and straight. Failed by crippling near on end.  |
| 3.33 X 4.18 X 14.97   |          | 4382                                       | 33.9                         | Failed by crippling.  |
| 4.35 X 4.32 X 20.55   |          | 3757                                       | 29.6                         | Knot near one end.  |
| 4.35 X 4.45 X 20.6    |          | 3540                                       | 27.1                         | Failed in centre.   |
| 4.41 X 4.45 X 20.6    |          | 3850                                       | 29.9                         | Clear.  |
| 2.5 X 3.42 X 27.5     |          | 3390                                       | 26.3                         | Clear and straight grained, but heavy season crack from side to side. Failed by bulging on season crack and then bending. |
| 3.48 X 3.50 X 32.25   |          | 4384                                       |                              | Grain not straight; heavy knot through centre; also ends not square. Burst apart along centre.                            |
| 2.75 X 4.05 X 41.0    |          | 3070                                       | 28.3                         | Straight grained. Failed at large knot 3 ins. from end by crippling.  |
| 2.75 X 4.02 X 40.95   |          | 3086                                       | 28.4                         | Straight grained; eight large knots. Failed by bending at two knots 19 ins. from one end concave to high side.            |

## RESULTS OF COMPRESSIVE TESTS ON NEW SPRUCE (B.C.)—Continued.

|                                 |      |       |  |
|---------------------------------|------|-------|--|
| $4.35 \times 4.50 \times 20.55$ | 3584 | 27.4  | Grain clear and parallel. Crippled at centre.  |
| $4.08 \times 4.35 \times 22.97$ | 3909 | 27.5  | Grain crinkled near one end. Failed there.   |
| $4.18 \times 4.35 \times 22.95$ | 3271 | 27.7  | Clear; straight; no knots. Failed at one end.  |
| $4.29 \times 4.35 \times 22.96$ | 3617 | 25.4  | Grain not quite parallel; knot near centre of one side at which piece failed.  |
| $4.20 \times 4.35 \times 22.95$ | 2834 | 28.2  | Grain not parallel. Failed by longitudinal shear, which passed through a knot.   |
| $4.25 \times 4.40 \times 22.9$  | 3774 | 26.1  | Failed at a knot near centre of one side.  |
| $4.24 \times 4.34 \times 22.94$ | 2973 | 25.1  | Failed by longitudinal shear.  |
| $4.12 \times 4.35 \times 23.00$ | 3560 | 27.2  | Failed at a knot.  |
| $4.10 \times 4.41 \times 23.00$ | 3680 | 25.7  | Grain parallel. Failed by crippling at a knot 6 ins. from one end.   |
| $4.25 \times 4.40 \times 23.0$  | 3382 | 27.9  | One season crack, did not affect the failure which was by crippling.   |
| $4.10 \times 4.40 \times 23.05$ | 3550 | 26.4  | Knot near one end. Crippled in body of piece at a distance from the knot.  |
| $4.09 \times 4.35 \times 23.06$ | 4229 | 25.6  | Grain clear and parallel. Crippled on one side.  |
| $2.97 \times 4.0 \times 15.1$   | 4908 | 26.7  | Clear and straight grained. Crippled two from end.   |
| $3.33 \times 4.1 \times 15.64$  | 3370 | 26.4  | Straight grained; large knot on middle of side. Failed near one end in clear wood.   |
| $4.72$ in diar. $\times 15.0$   | 3430 | 30.86 | Four deep medullary weathering cracks; a mass of knots at lower end; small pin knots at centre; ends not quite parallel. Crippled at lower end at knots. |
| $2.6 \times 4.1 \times 18.5$    | 5253 | 24.1  | Clear and straight grain; failed by crippling and bending 6 ins. from one end.   |
| $4.75$ in diar. $\times 60$     | 1862 |       |  |
| $4.75$ " $\times 60$            | 2708 |       |  |
| $4.75 \times 4.75 \times 60$    | 2351 |       |  |
| $4.75 \times 4.75 \times 60$    | 2275 |       |  |
| $4.75 \times 4.75 \times 60$    | 3104 |       |  |
| $4.75 \times 4.75 \times 60$    | 2660 |       |  |
| $4.75 \times 4.75 \times 60$    | 2351 |       |  |
| $4.75 \times 4.75 \times 60$    | 2306 |       |  |
| $4.75 \times 4.75 \times 60$    | 2661 |       |  |
| $4.62 \times 4.63 \times 60$    | 2431 |       |  |
| $4.62 \times 4.75 \times 60$    | 2416 |       |  |
| $4.62 \times 4.62 \times 60$    | 2420 |       |  |
| $4.75$ in diam. $\times 60$     | 2483 |       |  |
| $4.75$ " $\times 61$            | 2483 |       |  |
| $4.75$ " $\times 61$            | 3215 |       |  |

## RESULTS OF COMPRESSIVE TESTS ON

## OLD SPRUCE.

| Dimensions in inches. |   |      | Lengths. | Compressive Strength in lbs. per sq. inch. | Weight in lbs. per cub. ft. | Remarks.   |
|-----------------------|---|------|----------|--|-----------------------------|--|
| 2.54                  | × | 3.15 | ×        | 5.95                                       | 4375                        | 28.4   |
| 2.12                  | × | 2.97 | ×        | 10.12                                      | 4508                        | 28.4   |
| 2.42                  | × | 2.45 | ×        | 10.95                                      | 4367                        | 27.9   |
| 2.50                  | × | 3.20 | ×        | 11.25                                      | 3862                        | 28.4   |
| 2.18                  | × | 2.18 | ×        | 14.00                                      | 4842                        | 27.9   |
| 2.17                  | × | 2.18 | ×        | 13.40                                      | 4714                        | 27.9   |
| 3.20                  | × | 3.22 | ×        | 13.40                                      | 5825                        |  |
| 3.20                  | × | 3.21 | ×        | 13.28                                      | 5696                        |  |
| 3.17                  | × | 3.21 | ×        | 13.62                                      | 4900                        | Straight grained; knot at centre. Crippled at knot.  |
| 3.20                  | × | 3.20 | ×        | 13.43                                      | 5273                        | Straight grained; knot on corner at centre. Failed at knot.  |
| 2.80                  | × | 3.35 | ×        | 13.30                                      | 5139                        | Heavy knot through edge near centre. Crippled at knot.   |
| 2.80                  | × | 3.34 | ×        | 12.50                                      | 4818                        | Straight grained; knots near each end. Crippled and burst through large knot.  |
| 2.18                  | × | 2.18 | ×        | 16.00                                      | 4337                        | 27.9   |
| 3.53                  | × | 3.56 | ×        | 14.60                                      | 6329                        | Clear and straight grained. Crippled near end through a small injury like a nail hole.                                 |
| 2.60                  | × | 2.63 | ×        | 15.45                                      | 7339                        | Clear; straight grained. Crippled 5 ins. from end.   |
| 2.60                  | × | 2.75 | ×        | 16.25                                      | 3664                        | One small knot, but badly out of parallel. Failed at knot.   |
| 2.66                  | × | 2.65 | ×        | 15.57                                      | 6809                        | Straight grained; one small knot near end. Crippled first near centre through cant hook holes.                         |
| 2.80                  | × | 3.37 | ×        | 27.05                                      | 5116                        | Straight grain; knot 12 ins. from end. Crippled at knot.   |
| 2.80                  | × | 3.35 | ×        | 26.26                                      | 5096                        | Straight grain; knot 10 ins. from end. Crippled at a knot.   |
| 2.62                  | × | 2.75 | ×        | 17.72                                      | 5625                        | Clear, but grain very much out of parallel, as much as 3 ins. in 18 ins. Burst apart by shearing of unsupported fibre. |

## TENSILE STRENGTH.

The experiments were especially directed to the comparison of the tensile strength and stiffness of portions of the same stick, in different positions relatively to the heart.

In designing the form of the test-piece, it was of importance to make the head of such a depth as would prevent the central portions from being pulled through the head by shearing along the surface BC, and it was also necessary that the depth should not be inconveniently great. Wedge shaped holders (Fig. H) were adopted which would grip the



Fig. H.



Fig. K.

specimen along the faces AB. This form of holder was intended to increase the resistance to shear which is always much less than the tensile strength. As the tension on the test-piece increases, so also does the normal pressure upon the faces AB, Fig. K., and, therefore, so also does the resistance to shear along the surface BC. At first, the faces of the holders in contact with the specimen were left rough, but it was found that the roughness prevented the specimen from sliding in far enough to be gripped along the whole of the face AB, so that the bearing surface was practically limited to a comparatively small area near the top of the head. Thus it often happened that the specimen still failed by shearing along the surface BC. This difficulty was obviated by planing the faces of the holders.

The test-pieces were prepared from the uninjured portions of the beams, which had already been fractured transversely. The extensions of a length of ten inches of the specimen under gradually increased loads were measured by means of Unwin's extensometer until the total extension exceeded about one-eightieth of an inch. After this the extensometer was removed, and in many cases additional extension readings, up to the point of fracture, of a length of sixteen inches of the specimen, were measured by means of a steel rule and indicator clamped to the specimen at points 16-inches apart and allowed to slide over one another.

The results obtained are given in the following Tables and an examination of these will show:—

1st. That the increments of extension up to the point of fracture are almost directly proportional to the increments of load;

2nd. That the presence of knots is most detrimental both to the strength and to the stiffness, inasmuch as they practically diminish the effective sectional area, and also produce a curvature in the grain;

3rd. That wood near the heart possesses much less strength and much less stiffness than that more distant from the heart;

4th. That the strength and stiffness are also dependent upon the proportion of summer to spring growth;

5th. That irregularity of readings, both with the extensometer and with the rule, are chiefly due to the presence of a knot, or to curly or oblique grain caused by a knot.

Again, some of the Tables give the effects on various specimens, of alternately loading them and relieving them from their load, and from the experiments carried out up to date the following inferences may perhaps be drawn:—

If the specimen is clear, free from knots, and straight in the grain, and if no interval of rest is allowed, then for any given range of loads:

(a) The total extension is greatest during the first loading;

(b) The extensions due to the successive loadings continually diminish, tending to a minimum limit, so that the coefficients of elasticity increase, and therefore so also does the stiffness;

(c) By the successive unloadings a set is produced, which continually increases, but at a diminishing rate, and which tends to a maximum limit;

(d) When the specimen is allowed an interval of rest under the minimum load, the first total extension, when the loading is resumed, is greater than at the commencement, but continually diminishes, tending to a minimum limit, which possibly coincides with the maximum limit reached previous to the interval of rest.

So also, after the interval of rest, when the first set produced the specimen is from load, is greater than that previously produced, but gradually diminishes, in the succeeding releases from load, tending probably to a minimum limit coinciding with the maximum limit reached before the interval of rest.

These inferences are also in accord with similar experiments carried out by Mr. Kerry, B.A.Sc.

Special attention may be directed to the test of specimen 4, beam XXI. This specimen failed simultaneously at two sections, the wood seeming to be very brittle, and the character of the failure pointed to some inherent weakness in the timber itself. After a microscopic examination of the fractured sections, Professor Penhallow described the fractures as being "very regular and devoid of any fibrous character, having the exact appearance of a piece of glass. The lines of fracture followed the variations in thickness of structure longitudinally and transversely with great regularity. The peculiar brittleness can only be referred to some local molecular condition of unknown origin, possibly to a deficiency in the element of water."

The simultaneous failure at two sections of specimens 2 and 8 from White Pine beam XLVIII may probably be referred to a similar cause, and, as Professor Penhallow says, adequate explanations of such failures are still to be sought.

In the Tables the extensometer measurements are given in hundred-thousandths of an inch, and the rule measurements in hundredths of an inch.

With each table a diagrammatic section is also given, showing the part of the stick from which the several specimens have been taken.

DIAGRAMMATIC SECTIONS FOR TENSION SPECIMENS.



Fig. 118 Fig. 119. Fig. 120. Fig. 121. Fig. 122. Fig. 123. Fig. 124. Fig. 125. Fig. 126



Fig. 127 Fig. 128. Fig. 129. Fig. 130. Fig. 131. Fig. 132. Fig. 133

Results of tension tests on specimens 1 to 9 cut out of Douglas Fir Beam IX, and of repeatedly loading a specimen cut out of the same Beam. (Fig 118.)

| Loads<br>in<br>lbs.                        | Readings taken by Extensometer. |                    |                    |                    |                    |                    |                    |                    |       |
|--|---------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------|
|  | Specimen.                       |                    |                    |                    |                    |                    |                    |                    |       |
| 1<br>For-<br>ward.                         | 2<br>For-<br>ward.              | 3<br>For-<br>ward. | 4<br>For-<br>ward. | 5<br>For-<br>ward. | 6<br>For-<br>ward. | 7<br>For-<br>ward. | 8<br>For-<br>ward. | 9<br>For-<br>ward. |       |
| 100  | 0                               | 0                  | 0                  | 0                  | 0                  | 0                  | 0                  | 0                  | 0     |
| 200  | 89                              | 62                 | 63                 | 68                 | 86                 | 99                 | 98                 | 98                 | 65    |
| 400  | 221                             | 157                | 136                | 198                | 260                | 281                | 258                | 258                | 208   |
| 600  | 333                             | 277                | 251                | 319                | 432                | 461                | 418                | 418                | 347   |
| 800  | 481                             | 397                | 367                | 463                | 613                | 633                | 578                | 578                | 495   |
| 1,000                                      | 614                             | 515                | 484                | 679                | 788                | 807                | 738                | 738                | 620   |
| 1,200                                      | 743                             | 636                | 592                | 879                | 943                | 970                | 900                | 900                | 755   |
| 1,400                                      | 978                             | 755                | 712                | 1,049              | 1,135              | 1,132              | 1,057              | 1,057              | 890   |
| 1,600                                      | 1,105                           | 877                | 819                | 1,175              | 1,303              | 1,270              | 1,270              | 1,270              | 1,025 |
| 1,800                                      | 1,258                           | 988                | 953                | 1,573              | 1,50               | 1,429              | 0                  | 0                  | 1,159 |
| 2,000                                      | .....                           | 3                  | 1,121              | 0                  | 1,058              | 0                  | 10                 | 10                 | 1297  |
| 2,500                                      | .....                           | 12                 | 5                  | 6                  | 8                  | 10                 | 17                 | 12                 | 6     |
| 3,000                                      | .....                           | 19                 | 10                 | 10                 | 13                 | 16                 | 23                 | 20                 | 11    |
| 3,500                                      | .....                           | 29                 | 15                 | 16                 | 19                 | 24                 | 30                 | 27                 | 17    |
| 4,000                                      | .....                           | 37                 | 20                 | 20                 | 23                 | 32                 | 37                 | 34                 | 23    |
| 4,500                                      | .....                           | 47                 | 25                 | 25                 | 29                 | 40                 | 45                 | 41                 | 29    |
| 5,000                                      | .....                           | 55                 | 30                 | 30                 | 36                 | 52                 | 48                 | 48                 | 35    |
| 5,500                                      | .....                           | 62                 | 35                 | 35                 | 44                 | 60                 | 55                 | 55                 | 41    |
| 6,000                                      | .....                           | 69                 | 40                 | 40                 | 52                 | 73                 | 62                 | 62                 | 47    |
| 6,500                                      | .....                           | 79                 | 45                 | 48                 | 67                 | 70                 | 52                 | 52                 | 52    |
| 7,000                                      | .....                           | 89                 | 50                 | 60                 | 71                 | 79                 | 60                 | 60                 | 60    |
| 7,500                                      | .....                           | 94                 | 55                 | 68                 | 76                 | 89                 | 66                 | 66                 | 66    |
| 8,000                                      | .....                           | 100                | 60                 | 73                 | 90                 | .....              | 71                 | 71                 | 71    |
| 9,000                                      | .....                           | 70                 | 65                 | 75                 | 90                 | .....              | .....              | .....              | ..... |
| Total break-<br>ing weight<br>in lbs.      | 8,500                           | 9,500              | 9,240              | 10,850             | 4,820              | 6,960              | 7,965              | 8,500              | ..... |
| Brkg. weight<br>in lbs. per<br>sq. in.     | 11,902                          | 13,532             | 13,368             | 15,116             | 6,914              | 9,864              | 11,326             | 11,623             | 0     |
| Co-eff'nt of<br>elasticity in<br>lbs. .... | 1,830,500                       | 2,364,300          | 2,610,650          | 1,710,530          | 1,650,400          | 1,686,150          | 2,009,400          | 2,009,400          | 0     |
| Time of test<br>in minutes.                | 18                              | 25                 | 30 <sub>2</sub>    | 17                 | 18                 | 12                 | 12                 | 26                 | 82    |

Results of tension tests on specimens 1 to 7 cut out of Douglas Fir Beam X.

| Loads in<br>lbs.                           | Readings taken by  |                    |                    |                    |                    |                    |                    |                    |       |
|--|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------|
|  | 1<br>Ext.<br>Rule. | 2<br>Ext.<br>Rule. | 3<br>Ext.<br>Rule. | 4<br>Ext.<br>Rule. | 4<br>Ext.<br>Rule. | 4<br>Ext.<br>Rule. | 7<br>Ext.<br>Rule. | 6<br>Ext.<br>Rule. | Rule. |
| 100  | 0                  | 0                  | 0                  | 0                  | 0                  | 0                  | 0                  | 0                  | 0     |
| 200  | 89                 | 62                 | 63                 | 68                 | 86                 | 99                 | 98                 | 98                 | 65    |
| 400  | 221                | 157                | 136                | 198                | 260                | 281                | 258                | 258                | 208   |
| 600  | 333                | 277                | 251                | 319                | 432                | 461                | 418                | 418                | 347   |
| 800  | 481                | 397                | 367                | 463                | 613                | 633                | 578                | 578                | 495   |
| 1,000                                      | 614                | 515                | 484                | 679                | 788                | 807                | 738                | 738                | 620   |
| 1,200                                      | 743                | 636                | 592                | 879                | 943                | 970                | 900                | 900                | 755   |
| 1,400                                      | 978                | 755                | 712                | 1,049              | 1,135              | 1,132              | 1,057              | 1,057              | 890   |
| 1,600                                      | 1,105              | 877                | 819                | 1,175              | 1,303              | 1,270              | 1,270              | 1,270              | 1,025 |
| 1,800                                      | 1,258              | 988                | 953                | 1,573              | 1,50               | 1,429              | 0                  | 0                  | 1,159 |
| 2,000                                      | .....              | 3                  | 1,121              | 0                  | 1,058              | 0                  | 10                 | 10                 | 1297  |
| 2,500                                      | .....              | 12                 | 5                  | 6                  | 8                  | 10                 | 17                 | 12                 | 6     |
| 3,000                                      | .....              | 19                 | 10                 | 10                 | 13                 | 16                 | 23                 | 20                 | 11    |
| 3,500                                      | .....              | 29                 | 15                 | 16                 | 19                 | 24                 | 30                 | 27                 | 17    |
| 4,000                                      | .....              | 37                 | 20                 | 20                 | 23                 | 32                 | 37                 | 34                 | 23    |
| 4,500                                      | .....              | 47                 | 25                 | 25                 | 29                 | 40                 | 45                 | 41                 | 29    |
| 5,000                                      | .....              | 55                 | 30                 | 30                 | 36                 | 52                 | 48                 | 48                 | 35    |
| 5,500                                      | .....              | 62                 | 35                 | 35                 | 44                 | 60                 | 55                 | 55                 | 41    |
| 6,000                                      | .....              | 69                 | 40                 | 40                 | 52                 | 73                 | 62                 | 62                 | 47    |
| 6,500                                      | .....              | 79                 | 45                 | 48                 | 67                 | 70                 | 52                 | 52                 | 52    |
| 7,000                                      | .....              | 89                 | 50                 | 60                 | 71                 | 79                 | 60                 | 60                 | 60    |
| 7,500                                      | .....              | 94                 | 55                 | 68                 | 76                 | 89                 | 66                 | 66                 | 66    |
| 8,000                                      | .....              | 100                | 60                 | 73                 | 90                 | .....              | 71                 | 71                 | 71    |
| 9,000                                      | .....              | 70                 | 65                 | 75                 | 90                 | .....              | .....              | .....              | ..... |
| Total break-<br>ing weight<br>in lbs.      | 8,500              | 9,500              | 9,240              | 10,850             | 4,820              | 6,960              | 7,965              | 8,500              | ..... |
| Brkg. weight<br>in lbs. per<br>sq. in.     | 11,902             | 13,532             | 13,368             | 15,116             | 6,914              | 9,864              | 11,326             | 11,623             | 0     |
| Co-eff'nt of<br>elasticity in<br>lbs. .... | 1,830,500          | 2,364,300          | 2,610,650          | 1,710,530          | 1,650,400          | 1,686,150          | 2,009,400          | 2,009,400          | 0     |
| Time of test<br>in minutes.                | 18                 | 25                 | 30 <sub>2</sub>    | 17                 | 18                 | 12                 | 12                 | 26                 | 82    |

Results of repeatedly loading tension specimens 2 and 5 cut out of Douglas Fir Beam X. (Fig. 119).

Results of tension tests on specimens 1, 2, 5 cut out of Beam X, and of repeatedly loading specimens 3, 4, 6 cut out of same Beam. (Fig. 119.)

Results of tension tests on specimens cut out of Douglas Fir Beam X, and of repeatedly loading another specimen cut out of same Beam (Fig. 119).

Readings taken by Extensometer.

| Specimen                           | 7              |                               |           |           | 8         |           |           |           | 9         |         |           |         |
|------------------------------------|----------------|-------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------|-----------|---------|
|                                    | For-ward.      | Return.                       | For-ward. | Return.   | For-ward. | Return.   | For-ward. | Return.   | For-ward. | Return. | For-ward. | Return. |
| 100                                | 0              | .....                         | .....     | .....     | .....     | .....     | 0         | 0         | .....     | .....   | .....     | .....   |
| 200                                | 58             | 174                           | 172       | 172       | 176       | 171       | 179       | 179       | 69        | 78      | 222       | 228     |
| 400                                | 299            | 417                           | 410       | 412       | 413       | 416       | 418       | 417       | 341       | 316     | .....     | .....   |
| 600                                | 534            | 654                           | 656       | 656       | 659       | 660       | 665       | 661       | 468       | 430     | 158       | 453     |
| 800                                | 1900           | 1200                          | 776       | 776       | 776       | 776       | 776       | 776       | 602       | 545     | 463       | 459     |
| 1000                               | 1400           | 1600                          | 898       | 1019      | 1019      | 1023      | 1023      | 1027      | 731       | 760     | 680       | 689     |
| 1800                               | 2000           | 2000                          | 7030      | 9743      | 9743      | 1023      | 1023      | 1027      | 860       | 875     | 890       | 893     |
| Total breakg                       | Weight in lbs. | Brkg weight in lbs per sq. in | 2,296,350 | 2,296,350 | 2,296,350 | 2,296,350 | 2,296,350 | 2,296,350 | 983       | 1005    | 1015      | 1020    |
| Co efficient of elasticity in lbs. |                |                               |           |           |           |           |           |           | 1,1140    | 1,1140  | 1,1140    | 1,1140  |
|                                    |                |                               |           |           |           |           |           |           | 13,071    | 13,071  | 13,071    | 13,071  |
|                                    |                |                               |           |           |           |           |           |           |           |         |           |         |

\* After this, the 4th series of readings, the test-piece was allowed to rest for a period of 2 hours. On resuming the testing the reading was .000171.  
NOTE.—In test-pieces 7, 8 and 9, the grain was somewhat oblique to the direction of the axis.

Results of tension tests on specimens 1 to 6 cut out of Douglas Fir Beam XII, and of repeatedly loading specimen 3 cut out of same Beam. (Fig. 120).

| Loads in<br>lbs.                | Readings taken by |            |            |            |            |            | 3<br>Extension. |            |            |            |            |            |
|---------------------------------|-------------------|------------|------------|------------|------------|------------|-----------------|------------|------------|------------|------------|------------|
|                                 | 1<br>Extr.        | 2<br>Extr. | 3<br>Extr. | 4<br>Extr. | 5<br>Extr. | 6<br>Extr. | 1<br>Extr.      | 2<br>Extr. | 3<br>Extr. | 4<br>Extr. | 5<br>Extr. | 6<br>Extr. |
| 100                             | 0                 | 0          | 0          | 0          | 0          | 0          | 0               | 0          | 0          | 0          | 0          | 0          |
| 200                             | 79                | 82         | 69         | 59         | 73         | 79         | 75              | 57         | 54         | 57         | 70         | 82         |
| 400                             | 212               | 232        | 192        | 142        | 220        | 228        | 211             | 232        | 225        | 241        | 237        | 248        |
| 600                             | 383               | 382        | 313        | 263        | 284        | 369        | 384             | 363        | 299        | 299        | 269        | 248        |
| 800                             | 545               | 548        | 442        | 387        | 390        | 517        | 540             | 525        | 419        | 467        | 441        | 489        |
| 1,000                           | 704               | 720        | 600        | 505        | 509        | 666        | 702             | 670        | 539        | 478        | 465        | 475        |
| 1,200                           | 856               | 875        | 759        | 629        | 613        | 815        | 856             | 817        | 665        | 692        | 687        | 705        |
| 1,400                           | 1,005             | 1,032      | 907        | 749        | 722        | 955        | 1,009           | 953        | 792        | 697        | 715        | 705        |
| 1,600                           | 1,153             | 1,179      | 1,030      | 869        | 848        | 1,107      | 1,118           | 1,100      | 914        | 1,040      | 1,042      | 1,051      |
| 1,800                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 2,000                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 2,500                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 3,000                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 3,500                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 4,000                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 4,500                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 5,000                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 5,500                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 6,000                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 6,500                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 7,000                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 7,500                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 8,000                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 8,500                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 9,000                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 9,500                           |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 10,000                          |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 10,500                          |                   |            |            |            |            |            |                 |            |            |            |            |            |
| 11,000                          |                   |            |            |            |            |            |                 |            |            |            |            |            |
| Total break'g<br>weight in lbs. | 10,620            | 10,760     | 10,760     | 11,120     | ...        | 9,900      | 5,510           | 10,220     | 9,300      | 10,420     |            |            |
| Brkg weight<br>in lbs.p.sq.in.  | 14,886            | 15,327     | 15,040     | 15,655     | ...        | 13,909     | 7,823           | 14,360     | 13,066     | 14,640     |            |            |
| Co-eff'nt of<br>elast'cy in lbs | 1,791,800         | 1,805,050  | 2,001,650  | 2,307,200  | ...        | 2,486,700  | 1,920,900       | 1,834,100  | 1,895,500  | 1,960,450  |            |            |
| Time of test<br>in minutes.     | 10                | 10         | 10         | 16         | ...        | 12         | 9               | 8          | 9          | 41         |            |            |

In this test-piece the central portion was pulled through the head, so that its tensile strength exceeded the br'kg weight.

This test-piece failed at a section where the grain was curly from proximity to a knot.

This test-piece commenced to fail at a small knot.

In this test-piece the central portion was pulled through the head, so that its tensile strength exceeded the breaking weight.

Results of tension-tests on specimens cut out of Beam XIII, and of repeatedly loading other specimens cut out of the same Beam (Fig. 121).

Readings taken by

| Louds in<br>lbs.                     | Extensometer.                         |                      |              |                      |              |                      |              |                      |              |                      |              |                      | Extensometer. |                      |              |                      |              |                      |              |                      |              |                      |              |                      |              |                      |       |       |       |       |       |       |
|--------------------------------------|---------------------------------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|---------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|-------|-------|-------|-------|-------|-------|
|                                      | 1                                     |                      |              |                      |              |                      | Rule         |                      |              |                      |              |                      | 2             |                      |              |                      |              |                      | 3            |                      |              |                      |              |                      | 4            |                      |       |       |       |       |       |       |
|                                      | Forward                               | Re-<br>turn,<br>ward | For-<br>ward  | Re-<br>turn,<br>ward | For-<br>ward | Re-<br>turn,<br>ward | For-<br>ward | Re-<br>turn,<br>ward | For-<br>ward | Re-<br>turn,<br>ward | For-<br>ward | Re-<br>turn,<br>ward | For-<br>ward | Re-<br>turn,<br>ward | For-<br>ward | Re-<br>turn,<br>ward |       |       |       |       |       |       |
| 100                                  | 0                                     | 0                    | 0            | 0                    | 0            | 0                    | 0            | 0                    | 0            | 0                    | 0            | 0                    | 0             | 0                    | 0            | 0                    | 0            | 0                    | 0            | 0                    | 0            | 0                    | 0            | 0                    | 0            | 0                    | 0     | 0     |       |       |       |       |
| 200                                  | 64                                    | 172                  | 172          | 180                  | 182          | 198                  | 193          | 199                  | 202          | 202                  | 199          | 193                  | 199           | 202                  | 202          | 199                  | 215          | 216                  | 181          | 287                  | 191          | 239                  | 239          | 253                  | 253          | 253                  | 253   | 253   |       |       |       |       |
| 400                                  | 180                                   | 172                  | 172          | 180                  | 182          | 198                  | 193          | 199                  | 202          | 202                  | 199          | 193                  | 199           | 202                  | 202          | 199                  | 337          | 491                  | 420          | 300                  | 454          | 315                  | 435          | 435                  | 435          | 435                  | 435   | 435   | 435   | 435   |       |       |
| 600                                  | 295                                   | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 337          | 338                  | 420          | 300                  | 454          | 315                  | 435          | 435                  | 435          | 435                  | 435   | 435   | 435   | 435   |       |       |
| 800                                  | 406                                   | 409                  | 405          | 416                  | 418          | 435                  | 427          | 434                  | 428          | 435                  | 430          | 428                  | 435           | 430                  | 428          | 427                  | 472          | 613                  | 465          | 572                  | 418          | 620                  | 442          | 490                  | 485          | 505                  | 499   | 499   | 499   | 499   |       |       |
| 1,000                                | 510                                   | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 610          | 839                  | 591          | 723                  | 534          | 786                  | 553          | 706                  | 730          | 739                  | 748   | 751   | 751   | 751   | 751   |       |
| 1,200                                | 620                                   | 623                  | 627          | 637                  | 647          | 659                  | 651          | 661                  | 653          | 664                  | 656          | 651                  | 661           | 653                  | 664          | 656                  | 742          | 1015                 | 720          | 876                  | 632          | 1110                 | 821          | 1110                 | 1110         | 1110                 | 1110  | 1110  | 1110  | 1110  |       |       |
| 1,400                                | 727                                   | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 872          | 1179                 | 844          | 1030                 | 772          | 1110                 | 957          | 1110                 | 1110         | 1110                 | 1110  | 1110  | 1110  | 1110  |       |       |
| 1,600                                | 832                                   | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 1006         | .....                | 962          | 1185                 | 891          | .....                | 957          | 1110                 | 1110         | 1110                 | 1110  | 1110  | 1110  | 1110  |       |       |
| 1,800                                | 939                                   | 931                  | 951          | 975                  | 973          | 981                  | 983          | 983                  | 983          | 983                  | 983          | 983                  | 983           | 983                  | 983          | 983                  | 1140         | .....                | 1090         | 1102                 | 1012         | 1132                 | 1078         | 1102                 | 1102         | 1102                 | 1102  | 1102  | 1102  | 1102  |       |       |
| 2,000                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 1092         | 0                    | .....        | 1210                 | 1132         | 1132                 | 1132         | 1132                 | 1132         | 1132                 | 1132  | 1132  | 1132  |       |       |       |
| 2,500                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 5            | .....                | 10           | .....                | 15           | .....                | 20           | .....                | 25           | .....                | 30    | ..... | 34    | ..... | 39    | ..... |
| 3,000                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 10           | .....                | 15           | .....                | 20           | .....                | 25           | .....                | 30           | .....                | 34    | ..... | 39    | ..... | ..... | ..... |
| 3,500                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 15           | .....                | 20           | .....                | 25           | .....                | 30           | .....                | 34           | .....                | 39    | ..... | ..... | ..... | ..... | ..... |
| 4,000                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 20           | .....                | 25           | .....                | 30           | .....                | 34           | .....                | 39           | .....                | ..... | ..... | ..... | ..... | ..... | ..... |
| 4,500                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 25           | .....                | 30           | .....                | 34           | .....                | 39           | .....                | .....        | .....                | ..... | ..... | ..... | ..... | ..... | ..... |
| 5,000                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 30           | .....                | 34           | .....                | 39           | .....                | .....        | .....                | .....        | .....                | ..... | ..... | ..... | ..... | ..... | ..... |
| 5,500                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 34           | .....                | 39           | .....                | .....        | .....                | .....        | .....                | .....        | .....                | ..... | ..... | ..... | ..... | ..... | ..... |
| 6,000                                | .....                                 | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 39           | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | ..... | ..... | ..... | ..... | ..... | ..... |
| Total break g                        | 7520                                  | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | 9840         | 5140                 | 8720         | 7490                 | 11,620       | 4370                 | 9220         | .....                | .....        | .....                | ..... | ..... | ..... | ..... | ..... | ..... |
| Wt. in lbs.                          | Brkg weight<br>in lbs. per<br>sq.-in. | 10,638               | 13,945       | 7322                 | 1,2337       | 10,191               | 1,5,271      | 6278                 | 1,3,721      | .....                | .....        | .....                | .....         | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | ..... | ..... | ..... | ..... | ..... | ..... |
| Co. eff. of<br>elasticity in<br>lbs. | 2,609,400                             | 2,103,500            | 1,631,700    | 2,263,400            | 1,684,900    | 2,359,150            | 1,098,900    | 2,233,700            | .....        | .....                | .....        | .....                | .....         | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | .....        | .....                | ..... | ..... | ..... | ..... | ..... | ..... |

\* After this, the 4th series of readings, the test-piece was allowed to rest for  $\frac{1}{2}$  hours. On resuming the testing, the reading was .000182.

Results of repeatedly subjecting to tensile stress a specimen cut out of Beam XV. (Fig. 122.)

| Load in lbs.                                 | Specimen 1.<br>Readings taken by Extensometer. |       |       |       |       |       |       |       |       |        |       |       |
|--|--|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|-------|
|  | Forward  | Re-   | For-  | Re-   | For-  | Re-   | For-  | Re-   | For-  | Re-    | For-  | Re-   |
|  | ward.  | turn. | ward. | ward. | turn. | ward. | turn. | ward. | turn. | ward.  | turn. | ward. |
| 100  | 0  | 20    | 20    | 20    | 22    | 22    | 22    | 22    | 22    | 44     | 44    | 43    |
| 200  | 7.9  | 22.9  | 21.6  | 23.1  | 22.0  | 23.2  | 22.0  | 23.0  | 22.0  | 23.7   | 22.9  | 23.8  |
| 400  | 37.9   | 52.2  | 49.5  | 50.9  | 49.4  | 51.1  | 49.2  | 51.0  | 51.9  | 54.2   | 52.9  | 54.6  |
| 600  | 52.2   | 50.0  | 49.5  | 50.9  | 49.4  | 51.1  | 49.2  | 51.0  | 51.9  | 54.2   | 52.9  | 54.6  |
| 800  | 65.9   | 79.0  | 77.1  | 78.4  | 77.2  | 79.0  | 77.0  | 78.8  | 79.7  | 81.6   | 80.7  | 82.1  |
| 1,000  | 79.0   | 92.6  | 90.0  | 91.5  | 90.0  | 91.5  | 90.0  | 91.5  | 90.0  | 92.6   | 91.5  | 93.0  |
| 1,200  | 105.9  | 118.6 | 118.1 | 118.1 | 118.3 | 118.3 | 118.1 | 118.1 | 118.1 | 121.5  | 121.5 | 121.5 |
| 1,400  | 118.6  | 132.0 | 130.0 | 130.0 | 130.0 | 130.0 | 130.0 | 130.0 | 130.0 | 135.8  | 135.8 | 135.8 |
| 1,600  | 132.0  | 145.0 | 143.0 | 143.0 | 143.0 | 143.0 | 143.0 | 143.0 | 143.0 | 148.0  | 148.0 | 148.0 |
| 1,800  | 145.0  | 158.0 | 156.0 | 156.0 | 156.0 | 156.0 | 156.0 | 156.0 | 156.0 | 161.0  | 161.0 | 161.0 |
| 2,000  | 158.0  | 171.0 | 169.0 | 169.0 | 169.0 | 169.0 | 169.0 | 169.0 | 169.0 | 174.0  | 174.0 | 174.0 |
| 2,500  | 171.0  | 184.0 | 182.0 | 182.0 | 182.0 | 182.0 | 182.0 | 182.0 | 182.0 | 187.0  | 187.0 | 187.0 |
| 3,000  | 184.0  | 197.0 | 195.0 | 195.0 | 195.0 | 195.0 | 195.0 | 195.0 | 195.0 | 200.0  | 200.0 | 200.0 |
| 3,500  | 197.0  | 210.0 | 208.0 | 208.0 | 208.0 | 208.0 | 208.0 | 208.0 | 208.0 | 213.0  | 213.0 | 213.0 |
| 4,000  | 210.0  | 223.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 226.0  | 226.0 | 226.0 |
| 4,500  | 223.0  | 236.0 | 234.0 | 234.0 | 234.0 | 234.0 | 234.0 | 234.0 | 234.0 | 239.0  | 239.0 | 239.0 |
| 5,000  | 236.0  | 249.0 | 247.0 | 247.0 | 247.0 | 247.0 | 247.0 | 247.0 | 247.0 | 252.0  | 252.0 | 252.0 |
| 5,500  | 249.0  | 262.0 | 260.0 | 260.0 | 260.0 | 260.0 | 260.0 | 260.0 | 260.0 | 265.0  | 265.0 | 265.0 |
| 6,000  | 262.0  | 275.0 | 273.0 | 273.0 | 273.0 | 273.0 | 273.0 | 273.0 | 273.0 | 278.0  | 278.0 | 278.0 |
| 6,500  | 275.0  | 288.0 | 286.0 | 286.0 | 286.0 | 286.0 | 286.0 | 286.0 | 286.0 | 291.0  | 291.0 | 291.0 |
| 7,000  | 288.0  | 301.0 | 299.0 | 299.0 | 299.0 | 299.0 | 299.0 | 299.0 | 299.0 | 304.0  | 304.0 | 304.0 |
| 7,500  | 301.0  | 314.0 | 312.0 | 312.0 | 312.0 | 312.0 | 312.0 | 312.0 | 312.0 | 317.0  | 317.0 | 317.0 |
| 8,000  | 314.0  | 327.0 | 325.0 | 325.0 | 325.0 | 325.0 | 325.0 | 325.0 | 325.0 | 330.0  | 330.0 | 330.0 |
| 8,500  | 327.0  | 340.0 | 338.0 | 338.0 | 338.0 | 338.0 | 338.0 | 338.0 | 338.0 | 343.0  | 343.0 | 343.0 |
| 9,000  | 340.0  | 353.0 | 351.0 | 351.0 | 351.0 | 351.0 | 351.0 | 351.0 | 351.0 | 356.0  | 356.0 | 356.0 |
| 9,500  | 353.0  | 366.0 | 364.0 | 364.0 | 364.0 | 364.0 | 364.0 | 364.0 | 364.0 | 369.0  | 369.0 | 369.0 |
| Total breaking load in lbs.                  |  |       |       |       |       |       |       |       |       | 10000  |       |       |
| Breaking load in lbs. P. sq.in.              |  |       |       |       |       |       |       |       |       | 14,474 |       |       |
| Co-efficient of elasticity in lbs. 2,092,600 |  |       |       |       |       |       |       |       |       |        |       |       |

\* After this 8th series of readings the test-piece was allowed to rest for a period of 16 hours under the load of 100 lbs. On resuming the testing the initial reading was found to be unchanged.

Results of repeatedly subjecting to tensile stress a specimens 1 to 4 cut out of Beam XV.

Readings taken by.

Specimen

| Loads in lbs.                      | Extensometer. |         |           |         | Ext.      |         |           |         | Ext.      |         |           |         | Ext.      |         |           |           |
|------------------------------------|---------------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|-----------|
|                                    | 2             |         | 3         |         | 4         |         | Extr.     |         | 1         |         | Extr.     |         | Ext.      |         | Extr.     |           |
|                                    | For-ward      | Re-ward | For-ward  | Re-ward | For-ward  | Re-ward | For-ward  | Re-ward | For-ward  | Re-ward | For-ward  | Re-ward | For-ward  | Re-ward | For-ward  | Re-ward   |
| 100                                | 0             | 30      | 39        | 0       | 39        | 39      | 0         | 21      | 21        | 0       | 31        | 31      | 0         | 55      | 55        | 0         |
| 200                                | 62            | 224     | 209       | 229     | 216       | 199     | 239       | 230     | 157       | 174     | 70        | 211     | 224       | 220     | 178       | 189       |
| 400                                | 187           | 724     | 209       | 229     | 216       | 199     | 239       | 230     | 263       | 337     | 341       | 341     | 341       | 341     | 311       | 306       |
| 600                                | 313           | ...     | 453       | ...     | 479       | 457     | 470       | 509     | 495       | 366     | 395       | 361     | 446       | 499     | 470       | 441       |
| 900                                | 439           | ...     | 600       | ...     | 614       | 597     | 614       | 614     | 473       | 578     | 599       | 573     | 607       | 572     | 572       | 530       |
| 1,000                              | 694           | ...     | 707       | 729     | 710       | 746     | 764       | 756     | 738       | 760     | 739       | 703     | 703       | 703     | 642       | 642       |
| 1,200                              | 820           | 813     | ...       | ...     | 869       | ...     | 684       | ...     | 684       | ...     | 869       | ...     | 833       | ...     | 833       | 752       |
| 1,400                              | 949           | ...     | 1086      | 1086    | 1090      | 1130    | 1130      | 1152    | 785       | 884     | 899       | 879     | 1129      | 1129    | 1130      | 962       |
| 1,600                              | 1075          | ...     | 1201      | 1201    | 1217      | 1217    | 1288      | 1288    | 885       | 985     | 985       | 985     | 1091      | 1091    | 1091      | 847       |
| 1,800                              | ...           | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | 1220      | 1220    | 1220      | 956       |
| 2,000                              | ...           | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | 0         | 0       | 0         | 1073      |
| 2,200                              | ...           | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...       |
| 2,500                              | ...           | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...     | ...       | ...       |
| Total breaking weight in lbs.      | 10960         | ...     | 15346     | ...     | 7420      | ...     | 7720      | ...     | 10240     | ...     | 11000     | ...     | 102       | 102     | 102       | 3115      |
| Breaking weight in lbs. p. sq. in. | 2,205,250     | ...     | 2,144,850 | ...     | 10,610    | ...     | 11,117    | ...     | 15,004    | ...     | 15,619    | ...     | 11,686    | ...     | 11,686    | 2,626,200 |
| Co-efficient of elasticity in lbs. | 2,205,250     | ...     | 2,144,850 | ...     | 2,755,550 | ...     | 2,231,300 | ...     | 2,173,350 | ...     | 2,173,350 | ...     | 2,173,350 | ...     | 2,173,350 | 2,173,350 |

Results of repeatedly subjecting to tensile stress a specimen cut out of Beau XV. Fig. 122.

| Loads<br>in<br>lbs. | Readings taken by Extensometer. |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               | Rule. |
|---------------------|---------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------|
|                     | Forward.<br>Re-<br>turn.        | For-<br>ward.<br>Re-<br>turn. |       |
| 0                   | 58                              | 69                            | 69                            | 75                            | 75                            | 75                            | 75                            | 75                            | 77                            | 77                            | 77                            | 77                            | 77    |
| 100                 | 163                             | 190                           | 189                           | 202                           | 197                           | 212                           | 203                           | 212                           | 214                           | 214                           | 212                           | 212                           | 212   |
| 200                 | 245                             | 369                           | 361                           | 385                           | 368                           | 393                           | 374                           | 393                           | 373                           | 394                           | 301                           | 310                           | 285   |
| 300                 | 338                             | 430                           | 524                           | 554                           | 545                           | 567                           | 560                           | 574                           | 556                           | 576                           | 475                           | 477                           | 461   |
| 400                 | 620                             | 713                           | 809                           | 825                           | 826                           | 834                           | 834                           | 833                           | 834                           | 834                           | 739                           | 742                           | 723   |
| 500                 | 904                             | 1000                          | 1000                          | 1000                          | 1000                          | 1000                          | 1000                          | 1000                          | 1000                          | 1000                          | 825                           | 825                           | 720   |
| 600                 |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 700                 |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 800                 |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 900                 |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 1,000               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 1,200               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 1,400               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 1,600               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 1,800               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 2,000               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 2,200               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 2,400               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 2,600               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 2,800               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 3,000               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 4,000               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 4,500               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 5,000               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 5,500               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 6,000               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 6,500               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 7,000               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |
| 7,500               |                                 |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |                               |       |

|   |           |
|---|-----------|
| 8,000                                     | 38        |
| 8,500                                     | 41        |
| 9,000                                     | 43        |
| 9,500                                     | 47        |
| 10,000                                    | 50        |
| 10,500                                    | 55        |
| 11,000                                    | 60        |
| 11,500                                    | 64        |
| 12,000                                    | 69        |
| 12,500                                    | 73        |
| Total breaking weight }<br>in lbs.        | 12500     |
| Break'g. wght }<br>in lbs. per<br>sq. in. | 18001     |
| Co-efficient }<br>of elasticity in lbs.   | 3,141,900 |

\* After this the 10th series of readings, the test-piece was allowed to rest entirely free from load for a period of 46 hours.

Results of tension tests on specimens 1 to 11 cut out of Douglas Fir Beam XVII. (Fig. 123.)

| Loads<br>in<br>lbs.                 | Readings taken by |            |            |            |            |            |            |            |            |             |
|-------------------------------------|-------------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|
|                                     | 1<br>Extr.        | 2<br>Extr. | 3<br>Extr. | 4<br>Extr. | 5<br>Extr. | 6<br>Extr. | 7<br>Extr. | 8<br>Extr. | 9<br>Extr. | 10<br>Extr. |
| 100                                 | 0                 | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0           |
| 200                                 | 61                | 56         | 58         | 58         | 95         | 71         | 101        | 101        | 91         | 93          |
| 400                                 | 185               | 165        | 177        | 177        | 289        | 210        | 266        | 266        | 289        | 240         |
| 600                                 | 286               | 278        | 301        | 425        | 471        | 344        | 419        | 419        | 496        | 393         |
| 800                                 | 408               | 505        | 546        | 843        | 655        | 481        | 560        | 560        | 680        | 550         |
| 1,200                               | 618               | 620        | 669        | 1,057      | 1,057      | 745        | 848        | 848        | 1,073      | 854         |
| 1,400                               | 735               | 734        | 787        | .....      | .....      | 877        | 0          | 996        | 1,271      | 1,006       |
| 1,600                               | 834               | 845        | 909        | .....      | .....      | .....      | 1,144      | 1,144      | 1,159      | 1,159       |
| 1,800                               | 955               | 960        | 1,026      | 1,026      | 1,026      | 1,026      | 1,285      | 0          | 1,285      | 0           |
| 2,000                               | 1,060             | 1,023      | 1,153      | 1,153      | 1,153      | 1,153      | 3          | 3          | 9          | 9           |
| 2,200                               | 1,485             | 1,279      | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0           |
| 2,500                               | 5                 | 5          | 5          | 5          | 5          | 5          | 8          | 8          | 9          | 9           |
| 3,000                               | 11                | 10         | 10         | 10         | 10         | 10         | 13         | 13         | 17         | 17          |
| 3,500                               | 18                | 14         | 14         | 16         | 16         | 16         | 18         | 18         | 18         | 18          |
| 4,000                               | 22                | 19         | 19         | 22         | 22         | 22         | 25         | 25         | 32         | 32          |
| 4,500                               | 28                | 24         | 24         | 28         | 28         | 28         | 32         | 32         | 38         | 38          |
| 5,000                               | 32                | 29         | 29         | 32         | 32         | 32         | 37         | 37         | 43         | 43          |
| 5,500                               | 37                | 33         | 33         | 37         | 37         | 37         | 43         | 43         | 48         | 48          |
| 6,000                               | 42                | 38         | 38         | 42         | 42         | 42         | 48         | 48         | 53         | 53          |
| 6,500                               | 48                | 42         | 42         | 48         | 48         | 48         | 53         | 53         | 58         | 58          |
| 7,000                               | 53                | 48         | 48         | 53         | 53         | 53         | 58         | 58         | 6,500      | 6,500       |
| 7,500                               | 58                | 53         | 53         | 58         | 58         | 58         | 6,500      | 6,500      | 8,150      | 8,150       |
| 8,000                               | 63                | 58         | 58         | 63         | 63         | 63         | 6,500      | 6,500      | 8,933      | 8,933       |
| Total breaking weight in lbs.       | 5,500             | 5,500      | 5,500      | 5,500      | 5,500      | 5,500      | 3,200      | 3,200      | 5,180      | 5,180       |
| Breaking weight in lbs. per sq. in. | 7,755             | 11,631     | 11,631     | 11,631     | 11,631     | 11,631     | 4,230      | 4,230      | 7,035      | 7,035       |
| Co-efficient of elasticity in lbs.  | 2,578,350         | 2,518,500  | 2,518,500  | 2,518,500  | 2,518,500  | 2,518,500  | 1,377,000  | 1,377,000  | 2,036,200  | 1,978,450   |
| Time of test in minutes.            | 27                | 18         | 18         | 18         | 18         | 18         | 23         | 23         | 14         | 14          |

Results of tension tests on specimens 1 to 3 cut out of Douglas Fir Beam XIX. (Fig. 124.)

Readings taken by

| Loads in lbs. | 1     |               |               | 2     |               |               | 3     |               |               | 4     |               |               | 5     |               |               | 6     |       |  |
|---------------|-------|---------------|---------------|-------|---------------|---------------|-------|---------------|---------------|-------|---------------|---------------|-------|---------------|---------------|-------|-------|--|
|               | Extr. | $\frac{1}{2}$ | $\frac{3}{4}$ | Extr. |       |  |
| 100           | 0     | 0             | 0             | 0     | 0             | 0             | 0     | 0             | 0             | 0     | 0             | 0             | 0     | 0             | 0             | 0     | 0     |  |
| 200           | 50    | 50            | 58            | 50    | 57            | 58            | 50    | 57            | 58            | 50    | 61            | 61            | 58    | 58            | 58            | 58    | 58    |  |
| 400           | 190   | 183           | 212           | 190   | 190           | 190           | 190   | 190           | 190           | 190   | 190           | 190           | 190   | 179           | 179           | 179   | 179   |  |
| 600           | 320   | 290           | 315           | 296   | 296           | 296           | 296   | 296           | 296           | 296   | 299           | 299           | 299   | 276           | 276           | 276   | 276   |  |
| 800           | 448   | 384           | 423           | 422   | 422           | 422           | 422   | 422           | 422           | 400   | 478           | 478           | 478   | 324           | 324           | 324   | 324   |  |
| 1,000         | 589   | 520           | 550           | 544   | 544           | 544           | 544   | 544           | 544           | 520   | 620           | 620           | 620   | 490           | 490           | 490   | 490   |  |
| 1,200         | 741   | 619           | 661           | 661   | 661           | 663           | 663   | 663           | 663           | 642   | 760           | 760           | 760   | 620           | 620           | 620   | 620   |  |
| 1,400         | 864   | 730           | 790           | 790   | 782           | 782           | 782   | 782           | 782           | 766   | 898           | 898           | 898   | 584           | 584           | 584   | 584   |  |
| 1,600         | 1,008 | 869           | 902           | 902   | 901           | 901           | 901   | 901           | 901           | 890   | 1,041         | 1,041         | 1,041 | 695           | 695           | 695   | 695   |  |
| 1,800         | 1,128 | 970           | 1,034         | 1,034 | 1,033         | 1,033         | 1,033 | 1,033         | 1,033         | 1,142 | 1,142         | 1,142         | 1,142 | 795           | 795           | 795   | 795   |  |
| 2,000         | ..... | 3             | 1,090         | 0     | .....         | 3             | ..... | 3             | .....         | 1,151 | 0             | 1,140         | 0     | 898           | 898           | 898   | 898   |  |
| 2,200         | ..... | .....         | .....         | ..... | .....         | .....         | ..... | .....         | .....         | ..... | .....         | .....         | 0     | 1,013         | 1,013         | 1,013 | 1,013 |  |
| 2,500         | ..... | 9             | .....         | 8     | .....         | 9             | ..... | 9             | .....         | 5     | .....         | 5             | ..... | 1,148         | 1,148         | 1,148 | 1,148 |  |
| 2,600         | ..... | 11            | .....         | 12    | .....         | 13            | ..... | 13            | .....         | 10    | .....         | 10            | ..... | 1,148         | 1,148         | 1,148 | 1,148 |  |
| 3,000         | ..... | 14            | .....         | 16    | .....         | 16            | ..... | 16            | .....         | 11    | .....         | 11            | ..... | 1,148         | 1,148         | 1,148 | 1,148 |  |
| 3,200         | ..... | 19            | .....         | 19    | .....         | 19            | ..... | 19            | .....         | 18    | .....         | 18            | ..... | 1,148         | 1,148         | 1,148 | 1,148 |  |
| 4,000         | ..... | 25            | .....         | 21    | .....         | 24            | ..... | 24            | .....         | 23    | .....         | 23            | ..... | 22            | 22            | 22    | 22    |  |
| 4,500         | ..... | 29            | .....         | 26    | .....         | 30            | ..... | 30            | .....         | 23    | .....         | 23            | ..... | 21            | 21            | 21    | 21    |  |
| 5,000         | ..... | 35            | .....         | 31    | .....         | 35            | ..... | 35            | .....         | 23    | .....         | 23            | ..... | 21            | 21            | 21    | 21    |  |
| 5,500         | ..... | 42            | .....         | 36    | .....         | 39            | ..... | 39            | .....         | 31    | .....         | 31            | ..... | 32            | 32            | 32    | 32    |  |
| 6,000         | ..... | 49            | .....         | 40    | .....         | 43            | ..... | 43            | .....         | 34    | .....         | 34            | ..... | 35            | 35            | 35    | 35    |  |
| 6,500         | ..... | 54            | .....         | 54    | .....         | 54            | ..... | 54            | .....         | 54    | .....         | 54            | ..... | 41            | 41            | 41    | 41    |  |
|               |       |               |               |       |               |               |       |               |               |       |               |               |       | 70            | 70            | 70    | 70    |  |

|                                    |           |           |           |
|------------------------------------|-----------|-----------|-----------|
| 7,000                              | 76        | 45        | 58        |
| 7,500                              | 89        | 50        | 68        |
| 8,000                              | 93        | 53        | 73        |
| 8,500                              | 107       | 56        |           |
| 9,000                              | 112       | 59        |           |
| 9,500                              | 121       | 65        |           |
| 10,000                             |           | 70        |           |
| 10,500                             |           | 75        |           |
| 11,000                             |           | 82        |           |
| 11,500                             |           | 85        |           |
| 12,000                             | .....     | .....     | 90        |
| Total Breaking Weight in lbs.      | 11,140    | 12,600    | 10,700    |
| Break'g wgt. in lbs. per sq. in.   | 15,543    | 17,199    | 14,581    |
| Co-efficient of elasticity in lbs. | 2,082,700 | 2,407,950 | 2,320,950 |
| Time of test in minutes.           | .....     | 18        | 15        |
|                                    |           |           | 19        |
|                                    |           |           | 28        |
|                                    |           |           | 22        |

Results of tension tests on specimens cut out of Douglas Fir Beam XX, (Fig. 125,) and of the repeated loading of other specimens cut out of same Beam:—

| Loads in<br>lbs. | Readings taken by |         |          |         |               |         |          |         |               |         |          |         |
|------------------|-------------------|---------|----------|---------|---------------|---------|----------|---------|---------------|---------|----------|---------|
|                  | Extensometer.     |         |          |         | Extensometer. |         |          |         | Extensometer. |         |          |         |
|                  | Forward.          | Return. | Forward. | Return. | Forward.      | Return. | Forward. | Return. | Forward.      | Return. | Forward. | Return. |
| 100              | 0                 | 70      | 70       | 0       | 0             | 0       | 0        | 0       | 0             | 0       | 0        | 0       |
| 200              | 220               | 252     | 243      | 22      | 71            | 58      | 71       | 98      | 69            | 90      | 235      | 0       |
| 400              | 619               | 530     | 641      | 53      | 180           | 240     | 232      | 218     | 249           | 375     | 375      | 70      |
| 600              | 987               | 991     | 1,005    | 99      | 363           | 375     | 364      | 364     | 485           | 521     | 521      | 194     |
| 800              | 1,366             | 1,366   | 1,385    | 1,385   | 429           | 510     | 516      | 516     | 623           | 672     | 672      | 324     |
| 1,000            | .....             | .....   | 1,773    | 0       | 563           | 650     | 680      | 680     | 759           | 840     | 840      | 455     |
| 1,200            | .....             | .....   | .....    | 5       | 688           | 791     | 827      | 827     | 900           | 1,011   | 1,011    | 589     |
| 1,400            | .....             | .....   | .....    | 10      | 835           | 931     | 970      | 970     | 1,038         | 1,117   | 1,117    | 721     |
| 1,500            | .....             | .....   | .....    | 15      | .....         | 1,075   | 1,097    | 1,097   | 1,222         | 1,222   | 1,222    | 603     |
| 1,600            | .....             | .....   | .....    | 20      | 942           | 1,063   | 1,121    | 1,121   | 1,174         | 1,201   | 1,201    | 554     |
| 1,800            | .....             | .....   | .....    | 28      | 1,063         | 1,182   | 1,369    | 1,369   | 1,357         | 1,310   | 1,310    | 300     |
| 2,000            | .....             | .....   | .....    | 32      | 1,182         | 0       | 0        | 0       | 0             | 0       | 0        | 321     |
| 2,200            | .....             | .....   | .....    | 32      | 1,319         | .....   | .....    | .....   | .....         | .....   | .....    | .....   |
| 2,400            | .....             | .....   | .....    | 41      | .....         | .....   | .....    | .....   | .....         | .....   | .....    | .....   |
| 2,500            | .....             | .....   | .....    | 41      | .....         | .....   | .....    | .....   | .....         | .....   | .....    | .....   |
| 2,600            | .....             | .....   | .....    | 49      | .....         | .....   | 2        | 4       | 4             | 5       | 5        | 1,205   |
| 2,700            | .....             | .....   | .....    | 49      | .....         | 3       | .....    | .....   | .....         | .....   | .....    | .....   |
| 2,800            | .....             | .....   | .....    | 52      | .....         | 3       | .....    | .....   | .....         | .....   | .....    | 5       |
| 3,000            | .....             | .....   | .....    | 61      | .....         | 10      | 10       | 10      | 10            | 12      | 12       | 1,320   |
| 3,200            | .....             | .....   | .....    | 10      | .....         | 10      | 10       | 10      | 10            | 12      | 12       | 9       |



Results of tension tests on specimens cut out of Douglas Fir Beam XXI., and of the repeated loading of another specimen cut out of same Beam. (Fig. 126.)

| Loads in lbs.                     | Readings taken by |       |       |      |           |      |         |       |         |      |
|-----------------------------------|-------------------|-------|-------|------|-----------|------|---------|-------|---------|------|
|                                   | Extensometer.     |       |       | Rule | Extr.     |      | Rule    | Extr. |         | Rule |
|                                   | Forward.          | Re-   | For-  |      | Extr.     | Rule |         | Extr. | Rule    |      |
| 100                               | 0                 | 65    | 0     | ...  | 0         | ...  | 0       | 0     | ...     |      |
| 200                               | 65                | ...   | 69    | ...  | 105       | ...  | 116     | ...   | 113     |      |
| 400                               | 212               | 291   | 220   | ...  | 291       | ...  | 355     | ...   | 349     |      |
| 600                               | 391               | ...   | 360   | ...  | 455       | ...  | 630     | ...   | 600     |      |
| 800                               | 529               | 571   | 498   | ...  | 620       | ...  | 918     | ...   | 880     |      |
| 1,000                             | 663               | ...   | 626   | ...  | 810       | ...  | 1,244   | 0     | 1,229   |      |
| 1,200                             | 806               | 853   | 775   | ...  | 1,011     | ...  | ...     | ...   | 1,539   |      |
| 1,400                             | 948               | ...   | 918   | ...  | 1,234     | ...  | ...     | ...   | 0       |      |
| 1,500                             | ...               | ...   | ...   | ...  | ...       | ...  | 10      | ...   | 5       |      |
| 1,600                             | 1,090             | 1,118 | 1,050 | ...  | 1,428     | ...  | ...     | ...   | ...     |      |
| 1,800                             | 1,239             | ...   | 1,199 | ...  | 1,593     | ...  | ...     | ...   | ...     |      |
| 2,000                             | 1,385             | 1,385 | 1,340 | 0    | 1,731     | 0    | ...     | ...   | 14      |      |
| 2,500                             | ...               | ...   | 7     | ...  | 6         | ...  | ...     | ...   | 25      |      |
| 3,000                             | ...               | ...   | 12    | ...  | 11        | ...  | ...     | ...   | 37      |      |
| 3,500                             | ...               | ...   | 17    | ...  | 18        | ...  | ...     | ...   | 50      |      |
| 4,000                             | ...               | ...   | 22    | ...  | 24        | ...  | ...     | ...   | 60      |      |
| 4,500                             | ...               | ...   | 30    | ...  | 32        | ...  | ...     | ...   | ...     |      |
| 5,000                             | ...               | ...   | 37    | ...  | 41        | ...  | ...     | ...   | ...     |      |
| 5,500                             | ...               | ...   | 42    | ...  | 50        | ...  | ...     | ...   | ...     |      |
| 6,000                             | ...               | ...   | 50    | ...  | 56        | ...  | ...     | ...   | ...     |      |
| 6,500                             | ...               | ...   | 56    | ...  | 63        | ...  | ...     | ...   | ...     |      |
| 7,000                             | ...               | ...   | 61    | ...  | 76        | ...  | ...     | ...   | ...     |      |
| 7,500                             | ...               | ...   | 70    | ...  | 82        | ...  | ...     | ...   | ...     |      |
| 8,000                             | ...               | ...   | 85    | ...  | 92        | ...  | ...     | ...   | ...     |      |
| Total breaking weight in lbs.     | 8,240             | ...   | ...   | ...  | 8,100     | ...  | 1,830   | ...   | 4,480   |      |
| Br'king wgt. in lbs. per sq. in.  | 11,565            | ...   | ...   | ...  | 11,095    | ...  | 2,485   | ...   | 6,157   |      |
| Coefficient of elasticity in lbs. | 2,005,050         | ...   | ...   | ...  | 1,336,300 | ...  | 916,640 | ...   | 923,890 |      |
| Time of test in minutes.          | 44                | ...   | ...   | ...  | 35        | ...  | 14      | ...   | 27      |      |

Results of tension tests on specimens cut of an old Douglas Fir stringer, Beam XXII., and of the repeated loading of another specimen cut out of the same Beam.

| Loads in lbs.                     | Readings taken by |       |      |      |           |      |           |       |           |      |
|-----------------------------------|-------------------|-------|------|------|-----------|------|-----------|-------|-----------|------|
|                                   | Extensometer.     |       |      | Rule | Extr.     |      | Rule      | Extr. |           | Rule |
|                                   | Forward.          | Re-   | For- |      | Extr.     | Rule |           | Extr. | Rule      |      |
| 100                               | 0                 | ...   | ...  | ...  | 0         | ...  | 0         | 0     | ...       |      |
| 200                               | 79                | 141   | 141  | ...  | 117       | ...  | 90        | ...   | 60        |      |
| 400                               | 231               | 291   | 292  | ...  | 289       | ...  | 230       | ...   | 190       |      |
| 600                               | 389               | 440   | 439  | ...  | 416       | ...  | 376       | ...   | 319       |      |
| 800                               | 539               | 580   | 579  | ...  | 518       | ...  | 518       | ...   | 450       |      |
| 1,000                             | 690               | 730   | 723  | ...  | 635       | ...  | 649       | ...   | 588       |      |
| 1,200                             | 872               | 872   | 881  | ...  | 765       | ...  | 801       | ...   | 713       |      |
| 1,400                             | ...               | 1,030 | ...  | ...  | 895       | ...  | 929       | ...   | 847       |      |
| 1,600                             | ...               | 1,164 | ...  | ...  | 1,023     | ...  | 1,077     | ...   | 920       |      |
| 1,800                             | ...               | 1,340 | 0    | ...  | 1,169     | ...  | 1,205     | 0     | 1,096     |      |
| 2,000                             | ...               | 2     | ...  | ...  | 1,304     | 0    | 2         | ...   | 1,220     |      |
| 2,500                             | ...               | 9     | ...  | ...  | 8         | ...  | 5         | ...   | 4         |      |
| 3,000                             | ...               | 13    | ...  | ...  | 13        | ...  | 9         | ...   | 9         |      |
| 3,500                             | ...               | 20    | ...  | ...  | 18        | ...  | 16        | ...   | 13        |      |
| 4,000                             | ...               | 24    | ...  | ...  | 23        | ...  | 23        | ...   | 19        |      |
| 4,500                             | ...               | 30    | ...  | ...  | 29        | ...  | 30        | ...   | 23        |      |
| 5,000                             | ...               | 40    | ...  | ...  | 36        | ...  | 36        | ...   | 28        |      |
| 5,500                             | ...               | 46    | ...  | ...  | 42        | ...  | 42        | ...   | 33        |      |
| 6,000                             | ...               | 50    | ...  | ...  | 49        | ...  | 48        | ...   | 39        |      |
| 6,500                             | ...               | 55    | ...  | ...  | 56        | ...  | 54        | ...   | 45        |      |
| 7,000                             | ...               | 60    | ...  | ...  | 62        | ...  | 60        | ...   | 51        |      |
| 7,500                             | ...               | 67    | ...  | ...  | 71        | ...  | 68        | ...   | 57        |      |
| 8,000                             | ...               | 72    | ...  | ...  | 83        | ...  | 75        | ...   | 63        |      |
| 8,500                             | ...               | 80    | ...  | ...  | 86        | ...  | 86        | ...   | 70        |      |
| 9,000                             | ...               | 89    | ...  | ...  | 90        | ...  | 90        | ...   | 78        |      |
| 9,500                             | ...               | 98    | ...  | ...  | 98        | ...  | 98        | ...   | 86        |      |
| Total breaking weight in lbs.     | 8,800             | ...   | ...  | ...  | 10,000    | ...  | 8,320     | ...   | 9,340     |      |
| Br'king wgt. in lbs. per sq. in.  | 12,115            | ...   | ...  | ...  | 13,954    | ...  | 11,414    | ...   | 13,169    |      |
| Coefficient of elasticity in lbs. | 2,139,200         | ...   | ...  | ...  | 2,199,700 | ...  | 1,969,900 | ...   | 2,190,350 |      |
| Time of test in minutes.          | 17                | ...   | ...  | ...  | 18        | ...  | 14        | ...   | 14        |      |

Results of tension tests on specimens cut out of Old Spruce stringer, Beam LVII. (Fig. 128.)

| Loads<br>in<br>lbs.                | Readings taken by         |    |                           |    |                           |    |                           |    |                           |           |
|------------------------------------|---------------------------|----|---------------------------|----|---------------------------|----|---------------------------|----|---------------------------|-----------|
|                                    | Extr.<br>$\frac{1}{2}$ in |    | Extr.<br>$\frac{1}{2}$ in |    | Extr.<br>$\frac{1}{2}$ in |    | Extr.<br>$\frac{1}{2}$ in |    | Extr.<br>$\frac{1}{2}$ in |           |
| 100                                | 0                         | .. | 0                         | .. | 0                         | .. | 0                         | .. | 0                         | ..        |
| 200                                | 132                       | .. | 130                       | .. | 102                       | .. | 109                       | .. | 100                       | ..        |
| 400                                | 362                       | .. | 376                       | .. | 324                       | .. | 317                       | .. | 286                       | ..        |
| 600                                | 614                       | .. | 603                       | .. | 592                       | .. | 535                       | .. | 455                       | ..        |
| 800                                | 855                       | .. | 843                       | .. | 949                       | .. | 818                       | .. | 619                       | ..        |
| 1,000                              | 1,121                     | .. | 1,071                     | .. | 1,179                     | .. | 1,130                     | .. | 834                       | ..        |
| 1,200                              | 1,442                     | 0  | 1,303                     | 0  | 1,416                     | .. | 1,340                     | 0  | 1,017                     | ..        |
| 1,400                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | 1,022                     | ..        |
| 1,500                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | 1,060                     | ..        |
| 1,600                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | 1,169                     | ..        |
| 1,800                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| 2,000                              | ..                        | .. | 19                        | .. | 18                        | .. | ..                        | .. | ..                        | ..        |
| 2,500                              | ..                        | .. | 32                        | .. | 29                        | .. | ..                        | .. | ..                        | ..        |
| 3,000                              | ..                        | .. | 45                        | .. | 39                        | .. | ..                        | .. | ..                        | ..        |
| 3,500                              | ..                        | .. | 57                        | .. | 50                        | .. | ..                        | .. | ..                        | ..        |
| 4,000                              | ..                        | .. | 69                        | .. | 62                        | .. | ..                        | .. | ..                        | ..        |
| 4,500                              | ..                        | .. | 82                        | .. | 75                        | .. | ..                        | .. | ..                        | ..        |
| 5,000                              | ..                        | .. | 99                        | .. | 89                        | .. | ..                        | .. | ..                        | ..        |
| 5,500                              | ..                        | .. | ..                        | .. | 105                       | .. | ..                        | .. | ..                        | ..        |
| 6,000                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| 6,500                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| 7,000                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| 7,500                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| 8,000                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| 8,500                              | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| Total breaking weight {            | 5,500                     | .. | 5,700                     | .. | 6,830                     | .. | 5,660                     | .. | 6,970                     | ..        |
| in lbs.                            | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| Breaking weight in                 | 7,662                     | .. | 7,941                     | .. | 9,564                     | .. | 7,739                     | .. | 10,063                    | ..        |
| lbs. per sq. in.                   | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | .. | ..                        | ..        |
| Co-efficient of elasticity in lbs. | 1,032,050                 | .. | 1,202,350                 | .. | 1,025,850                 | .. | 1,069,350                 | .. | 1,818,950                 | ..        |
| Time of test in minutes.           | 18                        | .. | 17                        | .. | 16                        | .. | 17                        | .. | 18                        | ..        |
|                                    |                           |    |                           |    |                           |    |                           |    |                           | 16        |
|                                    |                           |    |                           |    |                           |    |                           |    |                           | 20        |
|                                    |                           |    |                           |    |                           |    |                           |    |                           | 88        |
|                                    |                           |    |                           |    |                           |    |                           |    |                           | 96        |
|                                    |                           |    |                           |    |                           |    |                           |    |                           | 9,000     |
|                                    |                           |    |                           |    |                           |    |                           |    |                           | 12,626    |
|                                    |                           |    |                           |    |                           |    |                           |    |                           | 1,903,200 |

Results of tension tests on specimens cut out of Old Spruce stringer,  
Beam LX. (Fig. 129.)

| Loads<br>in<br>lbs.                | Readings taken by |                    |            |                    |            |
|------------------------------------|-------------------|--------------------|------------|--------------------|------------|
|                                    | 5<br>Extr.        | Rule<br>5<br>Extr. | 6<br>Extr. | Rule<br>6<br>Extr. | 8<br>Extr. |
| 100                                | 0                 | 0                  | 0          | 0                  | 0          |
| 200                                | 54                | 127                | ..         | 90                 |            |
| 400                                | 191               | 276                | ..         | 259                |            |
| 600                                | 344               | 468                | ..         | 445                |            |
| 800                                | 497               | 652                | ..         | 610                |            |
| 1,000                              | 657               | 870                | ..         | 780                |            |
| 1,100                              | .....             | 960                | 0          |                    |            |
| 1,200                              | 811               | .....              | ..         | 950                |            |
| 1,300                              | .....             | .....              | ..         | 1,040              | 0          |
| 1,400                              | 967               | .....              | ..         |                    |            |
| 1,500                              | 1,040             | 0                  | 5          |                    |            |
| 1,600                              | .....             | .....              | ..         |                    | 5          |
| 1,800                              | .....             | 5                  | ..         |                    | 8          |
| 1,900                              | .....             | .....              | 11         |                    |            |
| 2,000                              | .....             | 9                  | ..         |                    | 11         |
| 2,300                              | .....             | .....              | 18         |                    |            |
| 2,400                              | .....             | 14                 | ..         |                    | 17         |
| 2,700                              | .....             | .....              | 25         |                    |            |
| 2,800                              | .....             | 20                 | ..         |                    | 23         |
| 3,100                              | .....             | .....              | 31         |                    |            |
| 3,200                              | .....             | 25                 | ..         |                    | 29         |
| 3,500                              | .....             | ..                 | 37         |                    |            |
| 3,600                              | .....             | 31                 | ..         |                    | 35         |
| 3,900                              | .....             | .....              | 45         |                    |            |
| 4,000                              | .....             | 35                 | ..         |                    | 41         |
| 4,300                              | .....             | .....              | 50         |                    |            |
| 4,400                              | .....             | 40                 | ..         |                    | 49         |
| 4,700                              | .....             | .....              | 57         |                    |            |
| 4,800                              | .....             | 48                 | ..         |                    | 54         |
| 5,000                              | .....             | 50                 | ..         |                    | 57         |
| 5,400                              | .....             | .....              | ..         |                    | 63         |
| 5,500                              | .....             | .....              | 70         |                    |            |
| 6,000                              | .....             | .....              | 80         |                    |            |
| 6,500                              | .....             | .....              | 88         |                    |            |
| Total breaking weight in lbs.      | 8,100             | 6,750              | 5,600      |                    |            |
| Breaking weight in lbs. p. sq. in. | 11,445            | 10,206             | 8,004      |                    |            |
| Co-efficient of elasticity in lbs. | 1,830,650         | 1,547,350          | 1,647,150  |                    |            |
| Time of test in minutes.           | 22                | 31                 | 22         |                    |            |

Results of tension tests on specimens cut out of Old Spruce Beam LXI, and of repeatedly loading another specimen cut out of same Beam. (Fig. 130.) Readings taken by

| Loads<br>in lbs.                      | Extensometer. |                    |               |                    | Rule          |                    |               |                    | Extensometer. |                    |               |                    | Rule          |                    |               |                    |
|---------------------------------------|---------------|--------------------|---------------|--------------------|---------------|--------------------|---------------|--------------------|---------------|--------------------|---------------|--------------------|---------------|--------------------|---------------|--------------------|
|                                       | 1             |                    | 2             |                    | 1             |                    | 2             |                    | 3             |                    | 4             |                    | 5             |                    | 6             |                    |
|                                       | For-<br>ward. | Re-<br>turn, ward. |
| 100                                   | 0             | 59                 | 59            | 68                 | 68            | 78                 | 78            | 78                 | 0             | 0                  | 0             | 0                  | 0             | 0                  | 0             | 0                  |
| 200                                   | 76            | 224                | 265           | 255                | 274           | 263                | 293           | 276                | 91            | 89                 | 82            | 82                 | 70            | 70                 | 79            | 79                 |
| 400                                   | 400           | 358                | 530           | 526                | 555           | 535                | 559           | 548                | 233           | 233                | 226           | 226                | 198           | 198                | 242           | 242                |
| 600                                   | 600           | 860                | 492           | 801                | 801           | 821                | 807           | 834                | 821           | 819                | 819           | 819                | 372           | 372                | 413           | 413                |
| 800                                   | 1,000         | 1,200              | 774           | 913                | 1,051         | 1,074              | 1,074         | 1,085              | 1,085         | 1,098              | 1,098         | 1,098              | 520           | 520                | 570           | 570                |
| 1,000                                 | 631           | 801                | 801           | 821                | 807           | 834                | 821           | 834                | 671           | 671                | 679           | 679                | 729           | 729                | 729           | 729                |
| 1,200                                 | 774           | 913                | 1,051         | 1,074              | 1,074         | 1,085              | 1,085         | 1,098              | 819           | 819                | 815           | 815                | 881           | 881                | 881           | 881                |
| 1,400                                 | 913           | 1,500              | 1,051         | 1,074              | 1,074         | 1,085              | 1,085         | 1,098              | 964           | 964                | 93            | 93                 | 1050          | 1050               | 1050          | 1050               |
| 1,500                                 | 1,500         | 1,800              | 1,051         | 1,074              | 1,074         | 1,085              | 1,085         | 1,098              | 1100          | 1100               | 1175          | 1175               | 1028          | 1028               | 1198          | 1198               |
| 1,800                                 | 2,000         | 2,400              | 2,500         | 2,800              | 3,000         | 3,400              | 3,500         | 3,800              | 4,000         | 4,400              | 4,500         | 4,800              | 5,000         | 5,400              | 5,500         | 5,800              |
| 2,000                                 | 2,400         | 2,500              | 2,800         | 3,000              | 3,400         | 3,500              | 3,800         | 4,000              | 4,400         | 4,500              | 4,800         | 5,000              | 5,400         | 5,500              | 5,800         | 6,000              |
| 2,400                                 | 2,500         | 2,800              | 3,000         | 3,400              | 3,500         | 3,800              | 4,000         | 4,400              | 4,500         | 4,800              | 5,000         | 5,400              | 5,500         | 5,800              | 6,000         | 6,340              |
| 2,500                                 | 2,800         | 3,000              | 3,400         | 3,500              | 3,800         | 4,000              | 4,400         | 4,500              | 4,800         | 5,000              | 5,400         | 5,500              | 5,800         | 6,000              | 6,640         | 6,900              |
| 2,800                                 | 3,000         | 3,400              | 3,500         | 3,800              | 4,000         | 4,400              | 4,500         | 4,800              | 5,000         | 5,400              | 5,500         | 5,800              | 6,000         | 6,724              | 7,000         | 7,000              |
| 3,000                                 | 3,400         | 3,500              | 3,800         | 4,000              | 4,400         | 4,500              | 4,800         | 5,000              | 5,400         | 5,500              | 5,800         | 6,000              | 6,881         | 9,905              | 9,905         | 9,905              |
| 3,400                                 | 3,500         | 3,800              | 4,000         | 4,400              | 4,500         | 4,800              | 5,000         | 5,400              | 5,500         | 5,800              | 6,000         | 6,850              | 1,830         | 2,070              | 2,070         | 2,070              |
| 3,500                                 | 3,800         | 4,000              | 4,400         | 4,500              | 4,800         | 5,000              | 5,400         | 5,500              | 5,800         | 6,000              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 3,800                                 | 4,000         | 4,400              | 4,500         | 4,800              | 5,000         | 5,400              | 5,500         | 5,800              | 6,000         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 4,000                                 | 4,400         | 4,500              | 4,800         | 5,000              | 5,400         | 5,500              | 5,800         | 6,000              | 6,850         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 4,400                                 | 4,500         | 4,800              | 5,000         | 5,400              | 5,500         | 5,800              | 6,000         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 4,500                                 | 4,800         | 5,000              | 5,400         | 5,500              | 5,800         | 6,000              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 4,800                                 | 5,000         | 5,400              | 5,500         | 5,800              | 6,000         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 5,000                                 | 5,400         | 5,500              | 5,800         | 6,000              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 5,400                                 | 5,500         | 5,800              | 6,000         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 5,500                                 | 5,800         | 6,000              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 5,800                                 | 6,000         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 6,850         | 6,850              | 15            | 15                 | 15            | 15                 |
| 6,000                                 | 6,400         | 6,500              | 6,800         | 7,000              | 7,500         | 8,000              | 8,500         | 8,500              | 61            | 61                 | 67            | 73                 | 73            | 73                 | 73            | 73                 |
| 6,400                                 | 6,500         | 6,800              | 7,000         | 7,500              | 8,000         | 8,500              | 8,500         | 8,500              | 50            | 50                 | 57            | 57                 | 57            | 57                 | 57            | 57                 |
| 6,500                                 | 6,800         | 7,000              | 7,500         | 8,000              | 8,500         | 8,500              | 8,500         | 8,500              | 56            | 56                 | 64            | 64                 | 64            | 64                 | 64            | 64                 |
| 6,800                                 | 7,000         | 7,500              | 8,000         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 50            | 50                 | 57            | 57                 | 57            | 57                 | 57            | 57                 |
| 7,000                                 | 7,500         | 8,000              | 8,500         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 50            | 50                 | 57            | 57                 | 57            | 57                 | 57            | 57                 |
| 7,500                                 | 8,000         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 50            | 50                 | 57            | 57                 | 57            | 57                 | 57            | 57                 |
| 8,000                                 | 8,500         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 50            | 50                 | 57            | 57                 | 57            | 57                 | 57            | 57                 |
| 8,500                                 | 8,500         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 50            | 50                 | 57            | 57                 | 57            | 57                 | 57            | 57                 |
| Total breaking weight in lbs.         | 8,500         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 8,500         | 8,500              | 6,640         | 6,640              | 6,900         | 6,900              | 6,900         | 6,900              | 6,900         | 6,900              |
| Brk. $\frac{w}{l}$ wt. in lbs./sq.in. | 12,792        | 12,792             | 12,792        | 12,792             | 12,792        | 12,792             | 12,792        | 12,792             | 9,724         | 9,724              | 9,981         | 9,981              | 9,981         | 9,981              | 9,981         | 9,981              |
| Co-eff. of elasticity in lbs.         | 2,063,515     | 2,063,515          | 2,063,515     | 2,063,515          | 2,063,515     | 2,063,515          | 2,063,515     | 2,063,515          | 1,851,540     | 1,851,540          | 1,851,540     | 1,851,540          | 1,851,540     | 1,851,540          | 1,851,540     | 1,851,540          |
| 1 in. of test in minute.              | 15            | 15                 | 15            | 15                 | 15            | 15                 | 15            | 15                 | 15            | 15                 | 15            | 15                 | 15            | 15                 | 15            | 15                 |

Results of tension-tests on specimens cut out of a 2 in. x 4 in. Red Pine scantling, and also of the repeated loading of another specimen cut out of same scantling. (Fig. 131.)

Readings taken by

| Loads in<br>lbs.                              | Extr.     | Rule  | Extr.         | Extr.        | Extr.         | Rule         | Extr. | Rule |
|---|-----------|-------|---------------|--------------|---------------|--------------|-------|------|
|   |           |       | For-<br>ward. | Re-<br>turn. | For-<br>ward. | For-<br>ward |       |      |
| 100   | 0         | ...   | 0             | 23           | 0             | ...          | 00    | ...  |
| 200   | 60        | ...   | 58            | ...          | 55            | ...          | 56    | ...  |
| 400   | 190       | ...   | 179           | 187          | 173           | ...          | 182   | ...  |
| 600   | 311       | ...   | 286           | ...          | 279           | ...          | 306   | ...  |
| 800   | 432       | ...   | 391           | 401          | 396           | ...          | 433   | ...  |
| 1,000   | 553       | ...   | 495           | ...          | 492           | ...          | 559   | ...  |
| 1,200   | 678       | ...   | 600           | 614          | 599           | ...          | 682   | ...  |
| 1,400   | 804       | ...   | 708           | ...          | 712           | ...          | 812   | ...  |
| 1,600   | 929       | ...   | 816           | 837          | 816           | ...          | 942   | ...  |
| 1,800   | 1053      | ...   | 927           | ...          | 925           | ...          | 1074  | ...  |
| 2,000   | 1179      | ...   | 1035          | 1045         | 1039          | ...          | 1202  | ...  |
| 2,200   | 1306      | ...   | 1143          | ...          | 1142          | ...          | 1335  | ...  |
| 2,400   | 1429      | 0     | 1257          | 1257         | 1257          | 0            | 1461  | 0    |
| 3,000   | .....     | 5     | .....         | .....        | 5             | .....        | 6     | ...  |
| 3,500   | .....     | 12    | .....         | .....        | 10            | .....        | 12    | ...  |
| 4,000   | .....     | 18    | .....         | .....        | 14            | .....        | 18    | ...  |
| 4,500   | .....     | 21    | .....         | .....        | 19            | .....        | 22    | ...  |
| 5,000   | .....     | 28    | .....         | .....        | 23            | .....        | 28    | ...  |
| 5,500   | .....     | 30    | .....         | .....        | 29            | .....        | 33    | ...  |
| 6,000   | .....     | 35    | .....         | .....        | 33            | .....        | 40    | ...  |
| 6,500   | .....     | 41    | .....         | .....        | 39            | .....        | 45    | ...  |
| 7,000   | .....     | 49    | .....         | .....        | 43            | .....        | 50    | ...  |
| 7,500   | .....     | 52    | .....         | .....        | 50            | .....        | 55    | ...  |
| 8,000   | .....     | 57    | .....         | .....        | 52            | .....        | 60    | ...  |
| 8,500   | .....     | 62    | .....         | .....        | 60            | .....        | 69    | ...  |
| 9,000   | .....     | ..... | .....         | .....        | 62            | .....        | 74    | ...  |
| 9,500   | .....     | ..... | .....         | .....        | .....         | .....        | ..... | ...  |
| Total brk'g weight }<br>in lbs.....           | 9,000     |       | 9,280         |              | 9,500         |              |       |      |
| Breaking weight in }<br>lbs. per sq. in....   | 12,689    |       | 12,775        |              | 14,372        |              |       |      |
| Co-efficient in elas- }<br>ticity in lbs..... | 2,279,850 |       | 2,554,150     |              | 2,247,350     |              |       |      |
| Time of test in min..                         | 24        |       | 20            |              | 30            |              |       |      |

Results of testing specimens cut out of White Pine Beam, and of repeatedly loading other specimens cut out of same Beam. (Fig. 131A.)

Specimen.

| Extr.                             | Measurements taken by Extensometer. |        |           |           |           |           |           |           | Ext.      | Measurements taken by Extensometer. |           |           |           |           |           |           |           | Ext.      |           |           |           |           |
|-----------------------------------|-------------------------------------|--------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                   | 3                                   |        |           |           | 7         |           |           |           |           | 8                                   |           |           |           | 6         |           |           |           | 4         |           |           |           |           |
| 0                                 | 0                                   | 0      | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0                                   | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         |           |
| 76                                | 81                                  | 241    | 268       | 405       | 569       | 732       | 748       | 914       | 1,082     | 1,069                               | 1,069     | 1,083     | 1,096     | 1,096     | 1,109     | 1,118     | 1,238     | 1,285     | 1,283     | 1,283     | 1,283     |           |
| 200                               | 239                                 | 400    | 469       | 579       | 600       | 748       | 752       | 899       | 1,040     | 1,069                               | 1,083     | 1,083     | 1,096     | 1,096     | 1,109     | 1,118     | 1,238     | 1,285     | 1,283     | 1,283     | 1,283     |           |
| 400                               | 469                                 | 579    | 600       | 748       | 752       | 752       | 752       | 899       | 1,040     | 1,069                               | 1,083     | 1,083     | 1,096     | 1,096     | 1,109     | 1,118     | 1,238     | 1,285     | 1,283     | 1,283     | 1,283     |           |
| 600                               | 680                                 | 748    | 752       | 752       | 752       | 752       | 752       | 899       | 1,040     | 1,069                               | 1,083     | 1,083     | 1,096     | 1,096     | 1,109     | 1,118     | 1,238     | 1,285     | 1,283     | 1,283     | 1,283     |           |
| 800                               | 899                                 | 914    | 914       | 914       | 914       | 914       | 914       | 1,040     | 1,040     | 1,069                               | 1,083     | 1,083     | 1,096     | 1,096     | 1,109     | 1,118     | 1,238     | 1,285     | 1,283     | 1,283     | 1,283     |           |
| 1,000                             | 1,040                               | 1,069  | 1,069     | 1,069     | 1,069     | 1,069     | 1,069     | 1,069     | 1,069     | 1,083                               | 1,083     | 1,083     | 1,096     | 1,096     | 1,109     | 1,118     | 1,238     | 1,285     | 1,283     | 1,283     | 1,283     |           |
| 1,200                             | 1,238                               | 1,283  | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283                               | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     |           |
| 1,400                             | 1,283                               | 1,283  | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283                               | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     |           |
| 1,600                             | 1,283                               | 1,283  | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283                               | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     |           |
| 1,800                             | 1,283                               | 1,283  | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283                               | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     | 1,283     |           |
| Total breaking load in lbs.       | 8,260                               | 7,440  | 9,136     | 8,470     | 12,969    | 11,561    | 1,729,400 | 1,654,500 | 1,729,400 | 1,729,400                           | 1,729,400 | 1,729,400 | 1,729,400 | 1,729,400 | 1,729,400 | 1,729,400 | 1,729,400 | 1,729,400 | 1,729,400 | 1,729,400 | 1,729,400 |           |
| Breaking load in lbs. per sq. in. | 12,252                              | 11,128 | 1,835,100 | 1,799,100 | 1,729,400 | 1,654,500 | 1,614,000 | 1,578,350 | 1,614,000 | 1,578,350                           | 1,614,000 | 1,578,350 | 1,614,000 | 1,578,350 | 1,614,000 | 1,578,350 | 1,614,000 | 1,578,350 | 1,614,000 | 1,578,350 | 1,614,000 | 1,578,350 |
| Coefficient of elasticity in lbs. |                                     |        |           |           |           |           |           |           |           |                                     |           |           |           |           |           |           |           |           |           |           |           |           |

Results of repeatedly loading specimens 2, 8 and 9 cut out of White Pine Beam XLVIII. (Fig. 131A.)  
Specimen.

|                                   | Measurements taken by Extensometer |       |       |       |       |       |           |           |       |       |       |       |           |       |       |       |       |       |
|-----------------------------------|------------------------------------|-------|-------|-------|-------|-------|-----------|-----------|-------|-------|-------|-------|-----------|-------|-------|-------|-------|-------|
|                                   | 2                                  |       |       |       |       |       | 9         |           |       |       |       |       | 8         |       |       |       |       |       |
| 100                               | 0                                  | ...   | ...   | ...   | ...   | ...   | 0         | ...       | ...   | ...   | ...   | ...   | 0         | ...   | ...   | ...   | ...   | ...   |
| 200                               | 92                                 | 274   | 274   | 274   | 274   | 274   | 78        | 251       | 256   | 256   | 256   | 256   | 92        | 254   | 285   | 285   | 292   | 324   |
| 400                               | 265                                | 591   | 591   | 591   | 591   | 591   | 232       | 548       | 564   | 564   | 564   | 564   | 254       | 423   | 423   | 423   | 423   | 340   |
| 600                               | 420                                | 605   | 605   | 605   | 605   | 605   | 392       | 548       | 565   | 565   | 565   | 565   | 591       | 613   | 613   | 613   | 613   | 340   |
| 800                               | 583                                | 603   | 591   | 591   | 591   | 593   | 548       | 564       | 570   | 570   | 570   | 570   | 591       | 619   | 663   | 663   | 663   | 671   |
| 1,000                             | 719                                | ...   | ...   | ...   | ...   | ...   | 719       | ...       | ...   | ...   | ...   | ...   | 760       | ...   | ...   | ...   | ...   | 672   |
| 1,200                             | 912                                | 1,075 | 1,075 | 1,075 | 1,075 | 1,075 | 912       | 1,075     | 1,075 | 1,075 | 1,075 | 1,075 | 929       | 1,030 | 1,030 | 1,030 | 1,030 | 677   |
| 1,400                             | 1,078                              | 1,078 | 1,079 | 1,079 | 1,079 | 1,083 | 1,078     | 1,079     | 1,079 | 1,079 | 1,079 | 1,079 | 1,098     | 1,102 | 1,102 | 1,102 | 1,102 | 1,158 |
| 1,600                             | ...                                | ...   | ...   | ...   | ...   | ...   | 1,078     | 1,078     | 1,078 | 1,078 | 1,078 | 1,078 | 1,098     | 1,158 | 1,158 | 1,158 | 1,158 | 1,162 |
| 1,800                             | ...                                | ...   | ...   | ...   | ...   | ...   | 1,078     | 1,078     | 1,078 | 1,078 | 1,078 | 1,078 | 1,192     | 1,192 | 1,192 | 1,192 | 1,192 | 1,192 |
| Total breaking load in lbs.       | 6,810                              | ...   | ...   | ...   | ...   | ...   | ...       | ...       | ...   | ...   | ...   | ...   | ...       | ...   | ...   | ...   | ...   | ...   |
| Break'g load in lbs per sq. in.   | 9,321                              | ...   | ...   | ...   | ...   | ...   | 8,316     | ...       | ...   | ...   | ...   | ...   | 9,624     | ...   | ...   | ...   | ...   | ...   |
| Co-efficient of elasticity in lbs | 1,676,200                          | ...   | ...   | ...   | ...   | ...   | 1,676,200 | ...       | ...   | ...   | ...   | ...   | 14,273    | ...   | ...   | ...   | ...   | ...   |
|                                   |                                    |       |       |       |       |       |           | 1,758,250 | ...   | ...   | ...   | ...   | 1,757,250 | ...   | ...   | ...   | ...   | ...   |

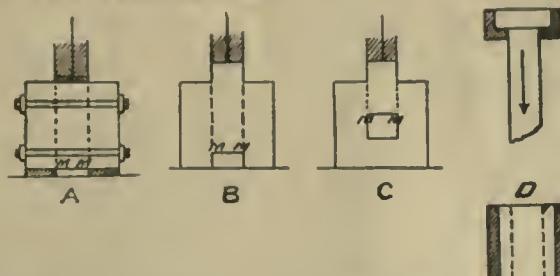
Specimens 2 and 8 failed at two sections simultaneously. Specimen 8, after the reading indicated by a \*, was allowed to rest under the minimum load of 400 lbs. for an interval of  $2\frac{1}{2}$  hours. When the loading was resumed the reading was .00324 in.

Results of testing specimens 1 and 2 cut out of Red Pine Beam XXXI, and of repeatedly loading specimens 2 and 3 cut out of same Beam. (Fig. 121B.)

|                                   | Measurements taken by Extensometer. |           |           |           |           |
|-----------------------------------|-------------------------------------|-----------|-----------|-----------|-----------|
|                                   | 1                                   | 2         | 1         | 2         | 3         |
| 100                               | 0                                   | 0         | 0         | 0         | 0         |
| 200                               | 77                                  | 99        | 117       | 60        | 92        |
| 400                               | 215                                 | 293       | 351       | 190       | 290       |
| 600                               | 319                                 | 478       | 571       | 313       | 489       |
| 800                               | 504                                 | 664       | 795       | 445       | 689       |
| 1,000                             | 648                                 | 854       | 1,005     | 571       | 887       |
| 1,200                             | 788                                 | 1,049     | 1,229     | 699       | 1,087     |
| 1,400                             | 928                                 | 1,245     | 1,445     | 828       | 1,102     |
| 1,600                             | 1,067                               | .....     | .....     | 936       | 1,113     |
| 1,800                             | .....                               | .....     | .....     | 1,084     | 786       |
| Total breaking weight in lbs.     | 8,460                               | 6,928     | 4,620     | 7,910     | 5,592     |
| Breaking wgt. in lbs. per sq. in. | 11,825                              | 9,378     | 6,274     | 10,889    | 8,090     |
| Coefficient of elasticity in lbs. | 1,960,500                           | 1,421,966 | 1,237,500 | 2,158,800 | 1,452,200 |
|                                   | .....                               | .....     | .....     | .....     | 1,953,100 |
|                                   | .....                               | .....     | .....     | 9,508     | .....     |
|                                   | .....                               | .....     | .....     | .....     | .....     |
|                                   | .....                               | .....     | .....     | .....     | .....     |

### SHEARING STRENGTH.

In the experiments, to determine the shearing strength of timbers, considerable difficulty was found in preparing suitable test-pieces which would not at the same time be liable to a large bending action. Blocks were prepared as shown by sketches A, B and C; but unless the sides were sufficiently strongly clamped, as in Fig. A, the specimens almost invariably opened at M, under an effect chiefly due to bending. The clamping, again, introduced a compression, which rendered it impossible to obtain the true shearing stress.



After a number of experiments, more satisfactory and reliable results were obtained by preparing test-pieces as shown by Figs. E and D. The bending action is by no means eliminated, and, generally speaking, it is practically impossible to frame timber joints subjected to a pure shear only. The shearing strengths, which are of importance, are the resistances along planes tangential and radial to the annular rings. An examination of the test-pieces shows that the shears are invariably along these planes.

Thus it will be observed that in the tangential shears, the fibre, both hard and soft, is sheared radially, in the radial shears tangentially, and invariably through the soft fibre.

With test-pieces of the form shown by Fig. D, the shearing strengths along the tangential and radial planes are obtained, while the compound shearing strength, which may be considered as the resultant of the tangential and radial shears, is obtained with the test-pieces of the form shown by Fig. E.

The following Tables give the results of experiments carried out with test-pieces and holders of the form described :—

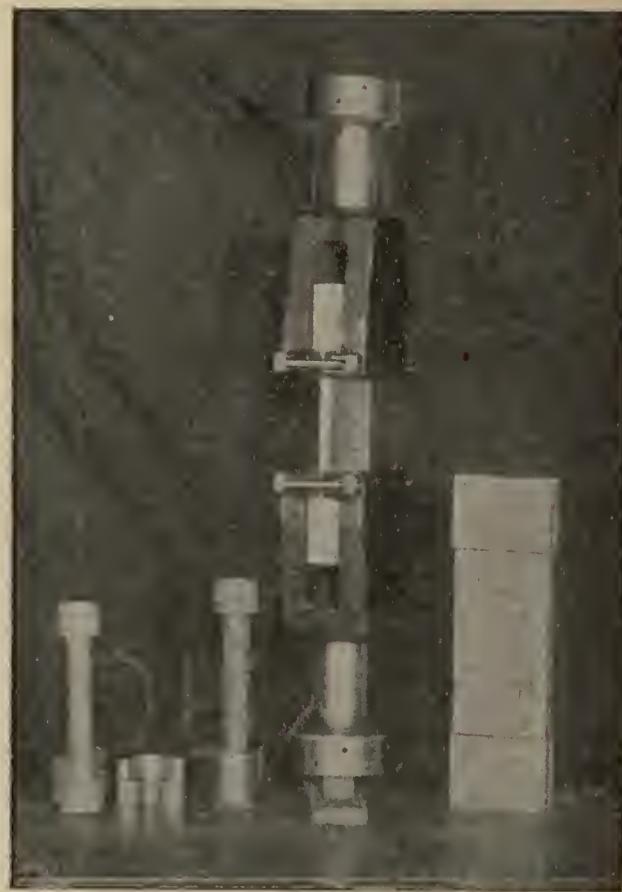
TABLE OF THE TANGENTIAL, RADIAL AND COMPOUND SHEARING STRENGTHS OF DOUGLAS FIR SPECIMENS CUT OUT OF THE SAME BEAM.

| Specimen. | Shearing stress per sq. in. in a direction tangential to the annular rings. | Specimen | Shearing stress per sq. in. in a direction at right angles to the annular rings. | Specimen. | Compound shears. |
|-----------|---|----------|--|-----------|------------------|
| No. 1     | 553   | No. 3    | 560  | *No. 13   | 471              |
| No. 2     | 568   | No. 5    | 484  | *No. 14   | 536              |
| No. 4     | 441   | No. 7    | 544  | No. 16    | 629              |
| No. 6     | 555   | No. 8    | 480  | No. 16    | 657              |
| No. 10    | 454   | No. 9    | 436  |           |                  |
| No. 11    | 415   | No. 12   | 480  |           |                  |

TABLE OF THE COMPOUND SHEARING STRENGTHS OF DOUGLAS FIR AND RED PINE SPECIMENS.

| Douglas Fir. |                                    | Red Pine. |                                    |
|--------------|------------------------------------|-----------|------------------------------------|
| Specimen.    | Shearing strength per square inch. | Specimen. | Shearing strength per square inch. |
| No. 1        | 802 lbs.                           | No. 1     | 648 lbs.                           |
| No. 2        | 727 "                              | No. 2     | 553 "                              |
| No. 3        | 886 "                              | No. 3     | 572 "                              |
| No. 4        | 795 "                              | No. 4     | 570 "                              |
| No. 5        | 706 "                              | No. 5     | 731 "                              |
| No. 6        | 649 "                              | No. 6     | 534 "                              |
| No. 7        | 746 "                              | No. 7     | 671 "                              |
| No. 8        |                                    | No. 8     | 698 "                              |
|              |                                    | No. 9     | 740 "                              |
|              |                                    | No. 10    | 757 "                              |

Not being altogether satisfied with these results, as the test-pieces did not seem to be of sufficient size to give results which could be considered of standard practical value, new holders, with spherical seats, were designed, and are shown in Fig. F.



E      F      C

With these holders, tests can now be made upon specimens in which the shearing surface has a width of 8 ins. and a depth limited by the tensile strength of the timber, the maximum shearing area being 96 sq. inches. The web of the specimens is usually about .7 in. in thickness, so that the depth should not exceed  $.35 \frac{1}{2} t$  being the tensile and  $s$  the shearing strengths in lbs. per sq. in. The depth of the shoulder forming the bearing for the pressure required to produce the shear is about  $\frac{1}{2}$  inch, and is made of only sufficient sectional area to resist failure by compression, as the deeper the shoulder the greater will be the bending action introduced.

From the Tables giving the results of the shearing experiments, the following inferences may be drawn :

- a. The shearing strength of the timbers is much less near the heart than at a distance from the heart.
- b. Generally speaking, the shearing strength increases with the weight per cubic foot.
- c. The shearing strength increases with the density of the annular rings, or rather with the proportion of hard to soft fibre.
- d. A failure sometimes occurs, for which it is difficult to find a complete explanation.

For example, the two specimens from Beam X, and designated in the Table by a \*, were precisely similar in dimensions and in weight, and also occupied precisely similar positions relatively to the heart in the stick from which they were cut. One of these specimens failed under a shear of 470.24 lbs. per sq. in., and the other under a shear of 301.84 lbs. per sq. in., so that the shearing strength of the latter was more than 35 per cent. less than that of the stronger specimen. A careful examination of the surfaces of fracture showed no visible difference in the specimens, and the only possible conclusion to be drawn seems to be either that one of the

specimens might have been drier than the other, and was therefore deficient in the element of water, or that the shoulders of the weaker specimen, at the end at which the failure occurred, were not cut very parallel with each other, and thus the greater part of the load might have been concentrated on one side.

e. As a result of the experiments, the average shearing strength of Douglas Fir in lbs. per square inch is 411.61, 377.14 or 403.605 according as the plane of shear is tangential, at right angles, or oblique to the annular rings.

In practice, therefore, it will be safe to adopt as the average co-efficients of shearing strength for Douglas Fir. 400 lbs. per sq. inch for shears tangential and oblique to the annular rings, and 375 lbs. per sq. inch for shears at right angles to the annular rings.

*Note.*—The numbers in brackets at the end of the total shears in the following Table correspond to the numbers in the diagrammatic sections, and indicate the position in the stick from which the specimens are taken. The letter H designates a specimen taken from the heart



Fig. 134



Fig. 135

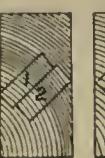


Fig. 136



Fig.



Fig. 137



Fig. 138

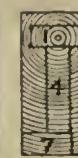


Fig. 139



Fig. 140



Fig. 141



Fig. 142



Fig. 142?



Fig. 143 Fig. 144.



Fig.



Left End  
Fig. 146

Table of Shearing Strengths in lbs. of specimens cut out of various Beams.

DOUGLAS FIR.

| Beam.                   | Tangential, |                  | Radial,          |                | Oblique, |             | Av. weight in lbs.<br>Per cub. ft. |
|-------------------------|-------------|------------------|------------------|----------------|----------|-------------|------------------------------------|
|                         | Total.      | Per sq. in.      | Total.           | Per sq. in.    | Total.   | Per sq. in. |                                    |
| IX.....<br>(Fig. 132.)  |             |                  |                  |                |          |             |                                    |
| 13,530<br>(1)           | 332.94      | 20,020<br>(4)    | 413.40           | 16,760<br>(2)  | 401.22   | 33.52       |                                    |
| 16,610<br>(1)           | 404.59      | .....            | .....            | 17,120<br>(2)  | 412.41   | .....       |                                    |
| 16,170<br>(1)           | 375.47      | .....            | .....            | 14,720<br>(3)  | 393.41   | .....       |                                    |
| 16,200<br>(3)           | 370.37      | .....            | .....            | 17,820<br>(3)  | 428.05   | .....       |                                    |
| 17,210<br>(1)           | 412.48      | .....            | .....            | 15,820<br>(2)  | 372.01   | .....       |                                    |
| 16,440<br>(1)           | 400.09      | .....            | .....            | 17,630<br>(3)  | 360.64   | .....       |                                    |
| .....                   | .....       | .....            | .....            | 19,570<br>(3)  | 367.89   | .....       |                                    |
| Average = 382.65        |             |                  |                  |                |          |             |                                    |
| X.....<br>(Fig. 133.)   |             |                  |                  |                |          |             |                                    |
| 19,380<br>(2)           | 435.31      | 14,450<br>(1)    | Average = 413.40 | 16,156<br>(3)  | 455.94   | 35.73       |                                    |
| 15,868<br>(2)           | 477.24      | .....            | 361.23           | 19,430*<br>(1) | 394.53   | .....       |                                    |
| 16,660<br>(2)           | 406.14      | .....            | .....            | 12,424*<br>(1) | 476.24   | .....       |                                    |
| .....                   | .....       | .....            | .....            | 21,501<br>(1)  | 301.84   | .....       |                                    |
| .....                   | .....       | .....            | .....            | 24,880<br>(4)  | 436.36   | .....       |                                    |
| .....                   | .....       | .....            | .....            | 23,760<br>(4)  | 511.41   | .....       |                                    |
| Average = 439.56        |             |                  |                  |                |          |             |                                    |
| XI.....<br>(Fig. 134.)  |             |                  |                  |                |          |             |                                    |
| 17,970<br>(1)           | 433.64      | 21,300<br>(2)    | Average = 361.23 | 20,350<br>(1)  | 433.44   | .....       |                                    |
| 19,760<br>(1)           | 416.51      | 21,300<br>(2)    | 457.50           | 21,500<br>(1)  | 398.15   | 34.57       |                                    |
| .....                   | .....       | 16,160<br>(2)    | 468.14           | 21,500<br>(1)  | 477.67   | .....       |                                    |
| .....                   | .....       | 17,100<br>(2)    | 377.81           | .....          | .....    | .....       |                                    |
| .....                   | .....       | .....            | .....            | .....          | .....    | .....       |                                    |
| Average = 425.07        |             |                  |                  |                |          |             |                                    |
| XII.....<br>(Fig. 135.) |             |                  |                  |                |          |             |                                    |
| 16,984<br>(3)           | 462.15      | 17,886<br>(1)    | Average = 438.31 | 438.31         | 437.92   | 31.81       |                                    |
| 14,552<br>(3)           | 395.22      | 16,980<br>(2)    | 464.60           | .....          | .....    | .....       |                                    |
| 15,330<br>(4)           | 414.78      | 14,954<br>(2)    | 441.01           | .....          | .....    | .....       |                                    |
| 15,210<br>(4)           | 409.97      | .....            | 385.41           | .....          | .....    | .....       |                                    |
| 17,440<br>(3)           | 424.70      | 14,920<br>(1)    | 355.18           | .....          | .....    | .....       |                                    |
| 12,940<br>(4)           | 443.79      | 15,350<br>(1)    | 367.07           | .....          | .....    | .....       |                                    |
| 12,860<br>(4)           | 428.80      | 13,260<br>(2)    | 331.20           | .....          | .....    | .....       |                                    |
| 19,600<br>(3)           | 478.37      | 14,610<br>(2)    | 350.55           | .....          | .....    | .....       |                                    |
| .....                   | .....       | Average = 432.22 | 385.86           | .....          | .....    | .....       |                                    |

## DOUGLAS FIR—Continued.

| Beam.                    | Tangential.  |   | Radial.  |   | Oblique.   |   | Av. wght in lbs<br>Per cub. ft. |
|--------------------------|--|---|--|---|--|---|---------------------------------|
|                          | Total.   | Per sq. in.   | Total.   | Per sq. in.   | Total.   | Per sq. in.   |                                 |
| XV.....<br>(Fig. 136.)   | 19,280 (3)<br>17,176 (3)<br>16,170 (4)<br>16,926 (4)   | 477.60<br>423.00<br>420.00<br>437.40                      | 15,260 (1)<br>14,165 (1)<br>17,94 (2)<br>16,050 (2)                | 369.49<br>401.50<br>431.56<br>387.31                        | .....<br>.....<br>.....<br>.....   | .....<br>.....<br>.....<br>.....                                      | 36.73                           |
| XVIII....<br>(Fig. 137.) | 15,272 (14)  | Average = 439.50  | Average = 397.46   | .....   | 15,495 (7)   | 359.  | .....                           |
| XIX.....<br>(Fig. 138.)  | 16,040 (6)<br>20,390 (7)<br>18,470 (13)<br>14,650 (13)<br>19,580 (13)<br>18,865 (7)<br>20,760 (13) | 409.1<br>422.6<br>395.3<br>340.<br>416.5<br>410.<br>440.8 | 14,430 (4)<br>14,220 (6)<br>14,350 (7)<br>15,700 (4)<br>15,200 (5) | 375.7<br>388.9<br>411.8<br>414.6<br>418.5<br>.....<br>..... | 14,470 (5)<br>20,850 (8)<br>17,180 (11)<br>12,500 (8)<br>11,625 (9)<br>19,420 (10) | Average = 406.15<br>= 402.<br>= 380.<br>= 389.7<br>= 347.2<br>= 382.1 | 38.4                            |
| XX.....<br>(Fig. 139.)   | 21,030 (7)<br>20,635 (7)<br>21,190 (7)<br>26,050 (7)   | 404.90<br>368.5<br>415.0<br>360.4                         | 15,855 (4)<br>14,270 (1)<br>17,630 (4)<br>19,040 (4)               | 401.90<br>276.7<br>252.0<br>378.2                           | .....<br>.....<br>.....<br>.....   | Average = 401.3   | .....                           |
| XXI.....<br>(Fig. 140.)  | 18,700 (5)<br>17,400 (2)<br>17,800 (2)   | Average = 350.<br>307.8<br>394.                           | 16,840 (1)<br>14,900 (3)<br>16,560 (3)                             | 309.37<br>291.0<br>273.2<br>307.1                           | 16,050 (1)   | 282.1   | .....                           |
|                          |  | Average = 350.60  |  | Average = 290.43  |  |   |                                 |

OLD DOUGLAS FIR.

| Beam.                   | Tangential.                       |             | Radial.     |             | Oblique.    |             | Av. wght in lbs |
|-------------------------|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-----------------|
|                         | Total.                            | Per sq. in. | Total.      | Per sq. in. | Total.      | Per sq. in. |                 |
| XXXI. ....              | 14,220 (1)                        | 314.        | 12,175 (7)  | 287.0       | 17,150 (9)  | 371.        | 31.33           |
| (Fig. 141)              | 13,370 (5)                        | 290.        | 14,630 (8)  | 333.0       | .....       | .....       | .....           |
|                         | Average =                         | 302.00      | Average =   | 310.00      | Average =   | 371.        | .....           |
|                         | RED PINE.                         |             |             |             |             |             |                 |
| XXXI. ....              | 20,780                            | 430.22 (1)  | .....       | .....       | 13,020 (H)  | 379.59      | 33.71           |
|                         | 20,850                            | 431.67 (1)  | .....       | .....       | 16,600      | 314.4       | .....           |
|                         | 20,700                            | 386.9       | .....       | .....       | 18,680      | 347.2       | .....           |
|                         | 18,440                            | 322.3       | .....       | .....       | 19,270      | 354.2       | .....           |
|                         | Average =                         | 392.77      |             |             |             | Average =   | 353.85          |
|                         | From 2 ins. x 4<br>ins. plank.... |             |             |             |             |             |                 |
| XLVIII. ....            | 22,440 (1)                        | 408.89      | 12,120 (7)  | 270.69      | 14,300 (3)  | 364.80      | 31.53           |
| (Fig. 145 and<br>145A.) | 20,565 (2)                        | 371.97      | 11,630 (7)  | 275.30      | 14,220 (5)  | 373.89      | .....           |
|                         | 16,160 (1)                        | 430.67      | .....       | .....       | 18,505 (6)  | 352.35      | .....           |
|                         | 16,045 (2)                        | 317.96      | .....       | .....       |             |             |                 |
|                         | Average =                         | 382.37      | Average =   | 272.99      | Average =   | 363.68      | .....           |
|                         | WHITE PINE.                       |             |             |             |             |             |                 |
| LVII. ....              | 12,100 (6)                        | 386.87      | 12,975 (3)  | 448.96      | 8,140 (4)   | 403.05      | 28.37           |
| (Fig. 142A.)            | .....                             | .....       | 11,390 (8)  | 408.88      | 9,280 (7)   | 447.85      | .....           |
|                         | .....                             | .....       | .....       | .....       | 13,460      | 404.64      | .....           |
|                         | .....                             | .....       | .....       | .....       | 16,075 (2)  | 457.84      | .....           |
|                         | .....                             | .....       | .....       | .....       | 13,200 (9)  | 456.59      | .....           |
|                         | .....                             | .....       | .....       | .....       | 12,480 (5)  | 322.00      | .....           |
|                         | Average =                         | 386.87      | Average =   | 428.92      | Average =   | 415.33      | .....           |
|                         | OLD SPRUCE.                       |             |             |             |             |             |                 |
| LX. ....                | 16,650 (4)                        | 302.7       | .....       | .....       | 17,130 (1)  | 292.        | .....           |
| (Fig. 142.)             | 14,250 (5)                        | 345.4       | .....       | .....       | 16,830 (3)  | 283.        | .....           |
|                         | 16,400 (4)                        | 297.4       | .....       | .....       |             |             |                 |
|                         | Average =                         | 315.16      |             |             |             |             |                 |
| LXI. ....               | 13,100 (3)                        | 329.1       | 14,800 (12) | 460.73      | 14,000 (12) | 436.78      | 28.6            |
| (Fig. 144.)             | .....                             | .....       | 14,840 (10) | 314.6       | 12,820 (11) | 299.1       | .....           |
|                         | .....                             | .....       | 12,470 (9)  | 312.        | 13,460 (2)  | 404.64      | .....           |
|                         | Average =                         | 329.1       | Average =   | 362.44      | Average =   | 380.17      | .....           |

N. B.—I wish to express my acknowledgment of the help given to me by Mr. C. B. Smith, M.A.E., in carrying out many of the experiments and in checking the calculations. I have also been ably assisted by Mr. Withcombe, the foreman of the Laboratories, who has devised many mechanical devices which have greatly facilitated the work.













Technol.

Author Bovey, H. T.  
Title The strength of Canadian Douglas-fir, etc.

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